SCIENCE

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THE IMPORTANCE OF GEOGRAPHICAL RESEARCH[1]

THIS year, when the British Association is holding its meeting in times of the utmost gravity, the changed conditions which have been brought about by this war must occupy the attention of all the sections to a greater or less extent, and our attention is being called to many fields in which our activities have been less marked or more restricted than they might have been, and where more serious study is to be desired. The same introspection may be usefully exercised in geography, for although that branch of knowledge has undoubtedly advanced in a remarkable degree during the last few decades, we have certainly allowed some parts of the subject to receive inadequate attention as compared with others, and the necessity for more serious study of many of its problems is abundantly evident.

Nor is the present occasion ill adapted to such an examination of our position, for when the British Association last met in this city, now twenty-eight years ago, the president of this section, General Sir Charles Warren, urged in his address the importance of a full recognition of geography in education on the grounds that a thorough knowledge of it is required in every branch of life, and is nowhere more important than in diplomacy, politics and administration.

Matters have certainly advanced greatly since that time, and a much fuller appreci-

[1] Presidential address to the Geographical Section of the British Association, Manchester, September, 1915.

ation of geography now exists than that which formerly prevailed. At the time of the address to which I have referred the serious study of geography in this country was on the eve of important developments. The Council of the Royal Geographical Society had for some time been urging the importance of geography being studied at the universities so that there should be an opportunity for advanced students to qualify themselves as scientific geographers by study and original research in the subject. The time had arrived for this ideal to become an accomplished fact, and in the following year, 1888, a reader in geography was appointed at Oxford University, and a lectureship in the same subject was established at Cambridge. Since then the advance has been steady and continuous not only in the increased attention given to the subject, but also in the way in which it is treated. The earlier bald and unattractive statistical presentation of the subject has now been almost everywhere replaced by a more intelligent treatment of it, in which the influences of the various environments upon the life which inhabits a region are appreciated, and the responses to such influences are followed up. Instruction in the subject is given by those who have seriously studied it, who realize its importance, and who are in a position to train up new scientific workers in the field of geography. Though much remains to be done, there should be now a steady output of geographical investigators capable of providing an ever-increasing supply of carefully observed data, which they will have classified methodically and discussed critically, in order that these may be utilized to form sound generalizations as to their relationships and sequence in accordance with the method which is employed in all scientific work.

In order that we may see what advance has been made in the scientific study of geography in this country during the last quarter of a century, we must turn to the results that have been attained by the activity of geographical investigators who have devoted themselves to the serious study of various phenomena, and the detailed investigation of particular regions. If we do so I think that we must admit that the number of original investigators in scientific geography who are extending its scope in this way is not so large as it might be, nor are we yet utilizing sufficiently all the material which is available to us. Any one who will examine the geographical material which has been published in any period which he may select for review will find that purely descriptive treatment still far outweighs the analytical treatment which alone can lead to definite advances in scientific geography. If pleasing descriptions of this or that locality are sought for, they are for the most part to be found readily in the very large amount of such material that has been and is being published each year by residents, travelers and explorers; but if information is desired in the prosecution of a piece of geographical research, we are checked by the lack of precise details. Few of this class of descriptions are sufficiently definite to enable the necessary comparisons to be made between one locality and others which are similarly situated; thoroughly quantitative treatment is for the most part lacking, and while a pleasing picture is drawn which is probably true in character, it is usually inadequately furnished with those definite facts which the geographer requires.

I propose, therefore, to examine a little more closely the question of geographical investigation and research in order to see where we stand and in what direction it behooves us to put forth our energies to the end that a branch of knowledge which is of

such importance shall rest upon that basis of detailed study and investigation which alone can supply the starting-point for further advance. The intricate and complicated character of the subject, the extent of its purview, the numerous points at which it touches and imperceptibly passes into other well-defined branches of knowledge, render the study of geography very liable to degenerate into a purely descriptive treatment of the earth's surface and all that is to be found thereon, rather than to follow the narrow path of scientific progress in which the careful collection of data furnishes the material for systematic discussion and study in order that trustworthy generalizations may be reached.

The opportunity to undertake long journeys through distant lands comes to a few of us, but this is not the only direction in which research can be profitably undertaken, for there is no part of these islands where a geographer can not find within his reach some geographical problem which is well worth working out, and which, if well and thoroughly done, will be a valuable contribution to his science. Even for such as can not undertake such field work the library will provide a host of subjects which have not received nearly the amount of attention and of careful study that they deserve. The one thing essential is that the study should be as thorough as possible, so that all the contributory lines of evidence shall be brought together and compared, and so that the result may prove to be a real addition to geographical science on which other workers may in their turn build.

For those who desire to undertake such investigations there is at any rate no lack of geographical material, for travelers, explorers, and others engaged in various occupations in every part of the world are continually recording their experiences and describing their surroundings in books and pamphlets; they recount their experiences to the Geographical Societies, who apparently have no difficulty in obtaining communications of wide interest for their meetings. Most portions of the British Empire as well as regions belonging to other nations are in these days more or less fully examined, surveyed and investigated with a view to their development, and those who undertake such work have ample opportunities for the most part for preparing descriptions of the lands in which they have sojourned and with which they are well acquainted. But although the material is so ample the quality of it is not generally such as makes it suitable for an adequate study of the phenomena or the region to which it relates. The ease with which a tract of country or a route can be described by the traveler, and the attractiveness of such a description of a little-known region, results in the provision of a vast quantity of geographical information, the greater part of which has probably been collected by those who have no adequate training in the subject. In such cases it is not uncommon for the writer to disclaim any geological or botanical knowledge, for instance, but the great majority of those to whom the opportunity is given to travel and see new lands and peoples are fully convinced of their competence to describe accurately and sufficiently the geography of the regions which they traverse. But any one who has had occasion to make use of such material in a serious investigation is only too well aware how little precise and definite information he will be able to extract from the greater part of this wealth of material, and in most cases this is due to the traveler's lack of geographical knowledge. He probably does not know the phenomena which should be observed in the type of region which he is

traversing, nor can he read the geographical evidence which lies patent to a trained observer at every point of the journey; much, therefore, of what he records may be of interest, but probably lacks data which are essential to the geographer if he is to understand the geographical character of the region and utilize it properly.

Thus it happens that although the amount of geographical material which is being garnered may be large, the proportion of it which is available for use in a scientific investigation of an area is smaller than is probably realized by those who have not made the experiment. And yet it is only by this scientific investigation of selected localities or of a single phenomenon and by working them out as thoroughly as possible that any real advance in geographical science can be made. The accounts of such pieces of work will not appeal to those who desire picturesque descriptions of little-known lands, but they will be welcomed by geographers who can appreciate the value of such studies. There should now be an ever-increasing number of such geographers, trained to proceed in their investigations by the true scientific method, and there should be a very considerable amount of sound work in various branches of the subject which aims at thoroughly investigating some phenomenon, or group of phenomena, so as to present a grouping of data, carefully verified and critically discussed, in order to arrive at conclusions which may form a useful addition, however small, to the sum of our geographical knowledge.

So far as I am able to judge, the output of serious work of this character is not nearly as large as it should be, and I would indicate some fields in which there is a lack of individual work of this character. Until more of it is undertaken we shall lack in this country the material from which the foundation of scientific geography can be built up, and while our own islands and the various parts of the British Empire furnish unrivalled opportunities for such work, there are still far too many subjects where the most thorough investigations have been made in other countries.

Mathematical geography presents a field for research which had comparatively little attention paid to it in this country. In many respects this part of the subject is peculiarly suitable for such treatment, since it admits of the employment of precise methods to an extent which is not always practicable in cases where so many of the factors can only be approximately defined. The determination of positions on the earth's surface is carried to great refinement in the national surveys of most civilized countries in order to furnish the necessary controls for the preparation of large-scale maps, but when we pass to the location of travellers' routes, where considerable allowance has to be made for the conditions under which the observations have to be taken, we find that very inadequate attention is usually paid to the discussion of the results. Usually a mean value for each latitude, longitude or azimuth is obtained by the computer, and he remains satisfied with this, so that when the route of another traveller follows the same line or crosses it at one or more points, it is almost impossible for the cartographer to say which of the two determinations of any position is entitled to the greater confidence. In this class of work, whether the results are obtained from absolute observations at certain points or from the direction of march, and the distance traversed, it is quite practicable to determine the range of uncertainty within which the positions of different points are laid down, and it is eminently desirable that this should always be done in order that the adjustment of various routes which may intersect in partially-known

regions may be adjusted in accordance with definite mathematical processes. Some important expeditions on which infinite labor and considerable sums have been expended have presented their results, in so far as they relate to the routes which have been followed and the position of points which have been determined, in such a way that it is impossible to say within what precision such positions have been determined, and consequently any combination of these results with those of later expeditions has to be carried out empirically, since adequate data are no longer available for the employment of better and more scientific methods.

This crude and unsatisfactory way of treating observations, which in many cases have been obtained under conditions of the greatest difficulty and even hardship, is largely due to the lack of interest which geographers have shown in this part of their subject. Methods of observation and methods of computation are rarely discussed before any of our geographical societies or in any of our publications, and it is only by such discussions that the importance of properly working out the available material at a time when the observer can be consulted on points which are doubtful, or where further explanation is desirable, becomes generally appreciated.

No set of physical or astronomical observations is ever discussed or even presented without the degree of precision or reliability being definitely stated; yet in geography this sound rule is too often neglected.

There are several regions where travellers' routes intersect which should provide ample material for the careful reduction and adjustment of the results. I fear, however, that there would be great difficulty in obtaining the original observations which are indispensable in such an investigation, and in the interest of research it is highly desirable that the original documents of all work of importance should be preserved and the place where they may be consulted recorded in the published account.

There is room in the geographical investigation of sea and land, even within the limits of the British Empire, for the employment of methods of observation and computation of the highest precision as well as of the simpler and more approximate kinds, but every one who presents the results of his work should deem it his first duty to state explicitly the methods which he employed, and the accuracy to which he attained, in such a form that all who make use of them can judge for themselves of the degree of their reliability.

In such work, while the instruments used are of great importance, too often the briefest description, such as "a 4-inch theodolite," is deemed sufficient. If the observer wishes his work to be treated seriously as a definite contribution to science we require to know more than this, and a clear account of the essentials of the instrument, a statement of its errors, and of the methods of observation adopted are the least that will suffice. The account of any expedition should treat so fully of the instruments, observations and computations utilized to determine the positions of places visited that any one can re-examine the evidence and form his opinion on the value of the results obtained. A mere tabular statement of accepted values, which frequently is all that is provided, is of small value from a scientific point of view. Probably one reason for this state of things is that too little attention is being paid by geographers to their instruments. Theodolites, levels, compasses, clinometers, tacheometers, plane-tables, pantographs, coordinatographs, planimeters, and the many other instruments which are used by the surveyor, the cartographer, the computer, have in no case

arrived at a final state of perfection, but it is seldom that we find a critical description of an instrument in our journals. Descriptions there are from time to time, but these are for the most part weak and insufficient. Not only is a technical description required, which treats fully of both the optical and mechanical details, but we need an extended series of observations with the instrument which have been made under the ordinary conditions of practical work, and these must be mathematically analyzed, and the degree of the reliability of the results clearly demonstrated. The description should be equally thorough and complete, including scale drawings showing the construction of the instrument as well as photographs of it. Nothing less than this is of any use to the scientific cartographer.

While I am on the subject of instruments I would draw attention to the importance of the whole history of the development of surveying instruments. In the latter part of the eighteenth century Great Britain provided the best class of surveying instruments to all countries of Europe, at a time when high-class geodetic work was being commenced in several countries; and about this time von Reichenbach spent a part of his time in this country working in the workshops of Dollond and learning this particular class of work. Upon his return to Bavaria he set up at Munich that establishment which soon provided instruments of the highest class for many of the cadastral surveys which were being undertaken in Central Europe. At Munich there is now a fine typical collection of such instruments, but in this country the early advances of British instrument-makers of surveying instruments are far from being adequately represented in our National Museum in a manner commensurate with their importance. The keen and enlightened zeal of geographers who are interested in this branch of the subject would doubtless quickly bring to light much still remaining that is of great interest, but which is yet unrecognized, while a closer attention to instrumental equipment would lead to improvements and advances in the types that are now employed. There is no modern work in this country on the development of such instruments, and references to their history are conspicuously rare in our journals, so that there is here an opportunity for those whose duties prevent them from undertaking travel or exploration of a more ambitious kind. In the same way, those whose opportunities of field work are few can find a promising field of study in the early methods and practise of surveying which have been discussed by many authors from classical times onwards, and for which a considerable amount of material exists.

In geodesy and surveying of high precision there is ample scope for all who are attracted by the mathematical aspect of the subject; the critical discussion of the instruments and methods employed and results obtained, both in this country and in other lands, provides opportunity for much work of real value, while its bearing upon geology, seismology, etc., has not yet been adequately treated here. The detailed history of this part of our subject is to be found in papers which have been published in the technical and scientific journals of other countries for the most part; here too little attention has been given to the subject, in spite of the large amount of geodetic work which has been executed in the British Empire, and which remains to be done in our colonies and over-seas dominions.

The final expression of the surveyor's detailed measurements is found in the map, and the adequate representation of any land surface on a map-sheet is both a science and an art. Here we require addi-

tional work on all sides, for there is hardly any branch of geography which offers so remunerative a field for activity as cartography. We need the cooperation of trained geographers to study requirements, and to make acquaintance with the limits of technical methods of reproduction, so that they may be in a position to deal with many questions which arise in the preparation of a map regarding the most suitable mode of presentation of data, a matter which is purely geographical, but which at the present time is too often left to the skilled draughtsman. Neither the compilation nor the reduction of maps are merely mechanical processes. The first requires great skill and care as well as technical knowledge and a sound method of treatment if the various pieces of work, which are brought together to make up the map of any considerable area, are to be utilized according to their true worth. This demands a competent knowledge of the work which has been previously done on the region, a first-hand acquaintance with the data collected by the earlier workers, and the critical examination of them in order that due weight may be given to the better material in the final result. This is not a task to be handed over to the draughtsman, who will mechanically incorporate the material as though it were all of equal accuracy, or will adjust discrepancies arbitrarily and not on any definite plan. Such preliminary preparation of cartographical material is a scientific operation which should be carried out by scientific methods and should be completed before the work reaches the draughtsman, who will then have but to introduce detail into a network of controls which has been prepared for him and of which the accuracy at all points has been definitely ascertained. Similarly in the second case the elimination of detail which must of necessity be omitted is an operation needing the greatest skill, a full understanding of the material available, and an adequate appreciation of the result which is being aimed at, such as is only to be found in a competent geographer who has made himself intimately acquainted with all the material which is available and has his critical faculty fully developed.

The use of maps has steadily increased of recent years, but we should look forward to an even more widely extended use of them in the future; and this will be greatly facilitated if there are geographers who have made themselves masters of the technique of map reproduction and, as scientific geographers, are prepared to select such data as are needed for any particular class of map on a well-considered method, and not by the haphazard procedure to which the want of a scientific study of cartographic methods must inevitably lead. The paucity of papers dealing with practical cartography and the compilation of maps is clear proof that this branch of the subject awaits far more serious attention than it now receives.

All these problems are well within the reach of the geographer to whom the opportunity of travel in other regions does not come, and in them he will find ready to his hand a field of research which is well worth working and which will amply repay any labor that is spent upon it. The same precise methods of investigation which are employed in the discussion of observations should be applied to all cartographic material in order to ascertain the exact standard of its reliability, in which is included not only the correctness of distance and direction, but also the accuracy of the information which has been incorporated in it; and these may be brought to bear also on those early maps of which so many are preserved in our libraries in this country. In this field of study several investigators

have already achieved results of great interest and value, but I think that they will be ready to admit that there is here a wide and profitable field of activity for many more workers who will study closely these early maps and, not being contented with verbal descriptions, will use quantitative methods wherever these are possible.

In the study of map projections some activity has been visible in recent years, and we may hope that those who have worked in this branch of the subject will see that British geography is provided with a comprehensive manual of this subject which will be worthy of the vast importance of cartography to the Empire. The selection of suitable projections is receiving much more attention than was formerly accorded to it, but the number of communications on this subject which reach geographical journals are few and far between. The subject is not one which can appeal strongly to the amateur geographer, but its importance renders it imperative that the scientific geographer who realizes its intimate bearing upon all his work should so arrange that the matter does not fall into the background on this account.

A closer relation and a more active cooperation between those who are prepared to work seriously at cartography and its various problems may reasonably be expected to raise the standard of that class of map which is used to illustrate books of travel, or works descriptive of a region. At the present time the inadequate character of many of the maps and plans which are reproduced in such publications shows clearly that the public demand for maps which have been compiled with a view to illustrating the volume in question is still very ineffective.

The whole subject of cartography, with its component parts of map projection, compilation, reproduction, cartometry and the history of its development, is so important, not only to the individual geographer but also to the advancement of scientific geography, that we should aim at fostering it and encouraging the study of it in every way, and it will be the zeal of individuals rather than the benevolent aid of institutions which will achieve this.

But it may be suggested that the lack of activity in mathematical geography is due to the somewhat specialized nature of the subject, and to the fact that the number of those who have received an adequate mathematical training and are prepared to devote themselves to geography is few. When we turn to physical geography in its treatment of the land we do find a field which has been more actively worked, for this is just the one to which the traveller's and explorer's observations should contribute most largely, and where therefore their material should be utilized with the best results. Even here there is room for much more work of the detailed and critical type, which is not merely general and descriptive, but starts from the careful collection of data, proceeds to the critical discussion of them, and continues by a comparison of the results with those obtained in similar observations in other regions.

To take a single branch of physical geography, the study of rivers, the amount of accurate material which has been adequately discussed is small. In our own country the rainfall of various river basins is well known through the efforts of a meteorological association, but the proportion of it which is removed by evaporation, and of that which passes into the soil, has only been very partially studied. Passing to the run-off, which is more easy to determine satisfactorily, the carefully measured discharges of streams and rivers are not nearly so numerous as they should be if the hydrography of the rivers is to

be adequately discussed; for although the more important rivers have been gauged by the authorities responsible for them in many cases, the results have usually been filed, and the information which has been published is usually a final value but without either the original data from which it has been deduced, or a full account given of the methods of measurement which have been employed. For the requirements of the authority concerned such a record is no doubt adequate, but the geographer requires the more detailed information if he is to coordinate satisfactorily the volume discharged with local rainfall, with changes in the rates of erosion or deposition, and the many other phenomena which make up the life-history of a river. Here too it is usually only the main stream which has been investigated; the tributaries still await a similar and even fuller study. A valuable contribution to work of this kind exists in the hydrographical study of the Medway and of the Exe which has been undertaken by a committee of the Royal Geographical Society during recent years, and this may serve as a guide to other workers; but, however welcome such a piece of work may be, I should much prefer to see the hydrography of a tributary of a river system worked out by a geographer as a piece of individual work, just as the geology or the botany or the zoology of a single restricted area is investigated by those whose interests are centered in these subjects.

In the same way we still know too little of the amounts of the dissolved and suspended matter which is carried down by our streams at various seasons of the year and in the different parts of their course. This class of investigation does not need very elaborate equipment, and may provide the opportunity for much useful study, which may be extended as information is increasingly acquired. In this way when numerous individual workers have studied the conditions prevailing in their own areas, and traced them through their seasonal and yearly variations, we shall possess a mass of valuable data with which we may undertake a revision of the results which have been arrived at in past years by various workers from such data as were then at their disposal.

In this one branch of the subject there is ample scope for workers of all interests in the measurement of discharges, in the determination of level, and of the movement of flood waves, in determining the amount of matter transported both in suspension and in solution, in tracing out the changes of the river channel, in following out the variation of the water-table which feeds the stream, in ascertaining the loss of water by seepage in various parts of its course, and generally in studying the hundred other phenomena which are well worth investigating, and which give ample scope for workers of all kinds and of all opportunities. There is work not only in the field, but also in the laboratory and in the library which needs doing, for the full account of even a single stream can only be prepared when data of all classes have been collected and discussed.

On the Scottish lakes much valuable scientific work has been done, and also on some of the English lakes, so that excellent examples of how such work should be done are available as a guide to any one who will devote his spare time for a year or two in making a thorough acquaintance with the characteristics and phenomena of any lake to which he has access.

Coast-lines provide another class of geographical control which repays detailed study, and presents numberless opportunities for systematic investigation and material for many profitable studies in geog-

raphy. The shores of these islands include almost every variety of type, and furnish exceptional opportunities for research of a profitable character, especially as lying on the border-line between the domain of the oceanographer on the one hand and the physiographer on the other. The precise methods of representation which are possible on the land have to give way to a more generalized treatment over the sea, and the shore line is liable to be handed over to the latter sphere, so that there is much interesting and useful work open to any one who will make an accurate and detailed study of a selected piece of coastline, coordinating it with the phenomena of the land and sea, respectively.

The teaching of Professor Davis in pressing for the employment of systematic methods in describing the landscapes with which the geographer has to deal has brought about a more rational treatment, in which due recognition is given to the structure of the area, and the processes which have moulded it, so that land forms are now for the most part described more or less adequately in terms which are familiar to all geographers and which convey definite associated ideas, in the light of which the particular description is adequately appreciated. It has been urged by some that such technical terms are unnecessary and serve to render the writings in which they occur intelligible only to the few; that any one should be able to express his meaning in words and sentences which will convey his meaning to all. There is no great difficulty in doing this, but in such descriptions to convey all that a technically worded account can give to those who understand its terms would be long and involved on account of the numerous related facts which would be included. It is consequently essential in all accurate work that certain terms should have very definite and restricted meanings, and such technical terms, when suitably chosen, are not only convenient in that they avoid circumlocution, but when used in the accepted sense at once suggest to the mind a whole series of related and dependent conditions which are always associated with it.

The compilation of a glossary of geographical terms has been in progress in this country for many years without having reached finality, and much of the difficulty which has been experienced is doubtless due to the fact that so many words have not been consistently used with a well-defined meaning. Such looseness of expression is more liable to occur in the case of foreign words which have been imported in the first case by writers who are not scientifically trained, and therefore do not use them in connection with a specified set of conditions. This, however, is unimportant if only scientific geographers, when they accept a term as a desirable addition to the geographical vocabulary, will associate it definitely with such conditions and use it consistently in that connection. As an instance I may quote the word "sadd," which etymologically means to block, or stop. This term was naturally and reasonably used to indicate masses of uprooted marsh vegetation which had been carried along by the current and, if checked at a sharp bend or a narrow point of the stream, blocked the channel. So long as it is used in this restricted sense it is a useful term to describe a phenomenon which occurs under certain definite conditions and which leads to equally well-defined geographical results. This use of it is associated with a meandering river-channel in an alluvial flood plain, where shallow lagoons occur, in which such marsh vegetation grows luxuriantly; when this vegetation is uprooted by storms and car-

ried by the rising water into the main stream it provides the drift material which makes up the block or "sadd."

But this term has been extended immoderately to mean the region in which these physical conditions occur, or the type of vegetation which grows under these conditions, and even the type of country where such conditions prevail. One writer has even used the word in describing the fossil vegetation of a character such as is associated with marsh lands.

The crystallization of such geographical terms into true technical terms is an important step in the futherance of scientific geography, but it must be done by the geographers themselves, and no means of doing this is more fruitful than the work of original research and investigation in definite areas or on specific problems.

It would take too long to discuss each branch of physical geography and indicate the opportunities for individual effort, but what has been said of one may be said of all the others. Not only in all parts of the Empire, but in these islands also there is ample opportunity for the detailed geographical study of single localities or individual phenomena, just as much as in geology, in botany, or in zoology; and it is these separate pieces of work which, when thoroughly carried out and critically discussed, provide the material on which wider generalizations or larger investigations can be based. Herein lies, therefore, the importance of the prosecution of them by as many workers as possible, and the value of communicating the results to others for criticism and for comparison with the results which they have obtained; for such work, if it can not be made accessible to other workers in the same and related fields, loses a large proportion of its value.

If we now consider some of the problems of human geography we shall find the need for such systematic study to be even greater; for the variable factors involved are more numerous than in physical geography, and many of them are difficult to reduce to precise statement; the quantitative study of the subject is therefore much more difficult than the qualitative or descriptive, so that the latter is too frequently adopted to the exclusion of the former. The remedy lies, I believe, in individual research into special cases and special areas where the factors involved are not too numerous, where some of them at least can be defined with some accuracy, and where, consequently, deductions can be drawn with some precision and with an accuracy which gives grounds for confidence in the result. The settlements of man, his occupations, his movements in their geographical relations are manifested everywhere, and subjects of study are to be found without difficulty, but their investigation must be based on actual observation, and on data which have been carefully collected and critically examined, so that the subject may be treated as completely as possible, and in such a way that the evidence is laid before the reader in order that he may form his own conclusions.

It is probable that some of the lack of precision which is to be found in this part of the subject is to be attributed to the want of precision in its terminology. For many things in human geography good technical terms are required, but these must be selected by those who have studied the type or phenomenon concerned and have a clear idea of the particular conditions which they desire to associate with the term; this is not the work of a committee of selection, but must grow out of the needs of the individual workers.

There is, it must be admitted, no small difficulty in using the same preciseness of

method in this portion of the subject as is readily attainable in mathematical geography, and is usually practicable in physiography; but at any rate it is undesirable to indicate any condition as the controlling one until all other possible influences have been carefully examined and have been shown to have less weight than that one which has been selected.

Whether the investigation deals with the settlements of man or his movements and means of communication it is important that in the first instance problems of a manageable size should be undertaken and thoroughly treated, leaving larger areas and wider generalizations until a sufficient stock of thoroughly reliable material which is in the form in which it can properly be used for wider aims is available.

The relation of geographical conditions to small settlements can be satisfactorily worked out if sufficient trouble is taken and all possible sources of information, both of present date and of periods which have passed away, are utilized. Such studies are of a real value and pave the way to more elaborate studies, but we need more serious study of these simpler cases both to set our facts in order and to provide a methodical classification of the conditions which prevail in this part of the subject. Out of such studies there will grow such a series of terms with well-defined associations as will give a real precision to the subject which it seems at the present time to lack.

The same benefit is to be anticipated from detailed work in relation to man's communications and the interchange of commodities in all their varied relations. Generalized and descriptive accounts are readily to be found, and these are for the most part supported by tables of statistics, all of which have their value and present truths of great importance in geography, but the spirit of active research which aims at clearing up thoroughly a small portion of the wide field of geographical activities has unequaled opportunities in the somewhat shadowy relations between the phenomena which we meet in this part of the subject, for focusing the facts better, and obtaining a more exact view of the questions involved.

Where the geography of states (political geography) is concerned the same need for original investigation as a basis for generalizations may be seen. At the present time there is much said about the various boundaries of states, and in general terms the advantages and disadvantages of different boundaries under varied conditions can be stated with fair approximation to accuracy. But I do not know of many detailed examinations of these boundaries or portions of them where full information of all the factors involved can be found set out in an orderly and authoritative manner, thus forming a sure foundation for the generalized description and providing the means of verifying its correctness or revising it where necessary.

Perhaps there is really more scientific research in geography being undertaken by individuals than I have given credit for, but certainly in geographical periodicals, and in the bibliographies which are published annually, the amount shown is not large; neither is the number of authors as large as might be expected from the importance and interest of the subject and from the activity of those centers where geography is seriously taught. There seems to be no reason why individual research on true scientific lines should not be as active in geography as it is in geology, botany, zoology, or any other branch of knowledge; and, just as in these, the real advance in the subject is dependent on such investigations rather than on travels and explora-

tions in little-known lands, unless these too are carried out scientifically and by thoroughly trained observers who know the problems which there await solution, and can read the evidence which lies before them on their route.

If research in these directions is being actively prosecuted, but the appearance of its results is delayed, let us seek out the retarding causes if there be any, and increase any facilities that may be desirable to assist individual efforts.

Short technical papers of a thoroughly scientific character, such as are the outcome of serious individual research, are, of course, not suitable for those meetings of geographical societies where the majority of the fellows present are not scientific geographers, but should be presented to small meetings of other workers in the same or allied fields, where they can be completely criticized. The reading, discussion and the publication of papers of this class are for geography a great desideratum, for it is in them and by them that all real advance in the subject is made, rather than by tales of travel, however interesting, if these are not the work of one trained in the subject, having a knowledge of what he should observe, and of what his predecessors have done in the same field. The regional aspect of geography in the hands of its best exponents has given to young geographers a wide and comprehensive outlook on the interaction of the various geographical factors in a region, the responses between the earth's surface and the life upon it, and the control that one factor may exercise upon another. In this form the fascination of geographical study is apparent to every one, but I sometimes wonder whether the exposition of such a regional study by one who is thoroughly master of the component factors, having a first-hand knowledge of all the material involved, and knowing exactly the reliability of each portion, impresses sufficiently upon the student the necessity of personal research into the details of some problem or phenomena in such a way as to gain a real working acquaintance with them; or does it on the other hand tend to encourage generalizations based on descriptive accounts which have not been verified, and where coincidences and similarities may be accepted without further inquiry as evidence of a causal connection which may not really exist? I imagine that the student may be attracted by the apparent simplicity of a masterly account of the geographical controls and responses involved, and may fail to realize that geographical descriptions, even though technically phrased, are not the equivalent of original quantitative investigation, either for his own education or as a contribution to the subject.

For these reasons I believe that societies can do far more good in the promotion of geography as a science by assisting competent investigators, by the loan of books and instruments, and by giving facilities for the discussion and publication of technical papers, than by undertaking the investigation of problems themselves.

Among the earlier presidential addresses of this section some have laid stress on the importance of the recognition by the state of geography in education; others have represented the great part which the geographical societies have played in supporting and advancing the subject; others again have urged the fuller recognition of geography by educational institutions. I would on this occasion attach especial importance to the prosecution of serious research by individuals in any branch of the subject that is accessible to them, to the discussion of the results of such work by others of like interests, and to the publication of such studies as having a real value in promoting the advancement of scientific geography.

H. G. LYONS

SOME ASPECTS OF SCIENTIFIC RESEARCH[1]

So much has been said of late on the subject of scientific research, its value to science, to the industries of the country and to the War Department, that it would seem fitting to use the first meeting of our club for a discussion of certain phases of this subject. Furthermore, research is an appropriate topic for discussion in our meetings since the Faculty Science Club was organized for the purpose of bringing each member into closer touch with the recent advances and research of the different fields of scientific endeavor.

Scientific research is, by the general public, one of the least understood and therefore least appreciated departments of science. The American people have been comparatively slow to recognize the value of the deeper and more fundamental researches in science. The national trait of desiring quick returns with a minimum expenditure of time and money has led to a certain superficial empiricism, which has gone under the garb of research. This empirical testing is even now the predominant principle in most of the so-called research laboratories of our factories and industrial plants. Even in our agricultural experiment stations, I venture to say that the major portion of the work is either routine or of the cut-and-dry type, without reference to fundamental principles.

Scientific research has perhaps as varied a meaning among scientists as ethics has in the field of law and jurisprudence. To illustrate, I might cite a paragraph from a recommendation of an applicant for the position now vacant in my department. The employer states concerning Mr. X that

> His particular work, aside from some analytical work, has been the care and conduct of the State Food Exhibit, and he has done good research work in the taking of ice-cream samples, which has been of great value to the department.

To some the term research is so comprehensive that it might properly be applied to a man's search for the best trail leading to the summit of a mountain peak, or to the prospector's investigation of the slopes of Mount Shasta. To me research means something entirely different. The personal contact with some of the leading research men of the day and an acquaintance with the writings and views of others of their type, have moulded a definite concept in my mind of the meaning of this term. To another this concept might seem erroneous, and consequently it behooves me to exercise a little charitable tolerance until I or he will have new light thrown upon the subject.

Scientific research is the slow, laborious process of laying bare, one by one, the facts and truths of nature, which have a definite bearing upon the fundamental and general principles involved in the problem. The isolation of a new chemical compound, the invention of a machine or piece of apparatus, or the discovery of a new force in nature would not necessarily be research. Only as these are units in the larger and more fundamental problem could they be included under that head. An illustration may make this point a little clearer: Some fifteen years ago Professor H. N. Morse, of Johns Hopkins University, undertook the problem of determining whether the osmotic pressure of solutions obeys the laws of Boyle, Gay Lussac and Avogadro for gases. He assumed that this could be demonstrated inside of two or three years. He learned, however, that he was unable to make or procure one satisfactory osmotic pressure cell the first year, but during that period worked out the proper clay mixtures for such cells and the methods for purifying the clays and moulding and burning the

[1] Address by the president of the Faculty Science Club of the University of Nevada, read at the opening session, September 23, 1915.

cells. The second year was occupied largely in working out and depositing a satisfactory semipermeable membrane in the cells, the third year, in making a sufficiently strong and accurate manometer and the means of joining the manometer to the cells. The following two years were required for constructing constant temperature rooms and baths where osmotic-pressure readings could be taken without temperature fluctuations in the cells. It was then five or six years from the time he started the work until he could make the first reliable set of osmotic pressure readings. During all this time Professor Morse was assisted by one or two men besides the three or four graduate students who worked with him each year. The following eight or ten years he made osmotic-pressure observations with glucose and cane sugar in water solutions at temperatures from 0 to 80 degrees.

He has finally established that the osmotic pressure of dilute solutions obeys the gas laws. Each individual unit of this great work, upon which the score or more candidates received their doctor's degree, could only be called research work when considered as a part of the general problem. Each man's contribution was of course a separate piece of original investigation.

The German army, more than any other agency, is now forcing upon the world the value of chemical research. It is the German chemists who have won the battles in Russia, Belgium and France, and the United States is now sitting up and taking notice, with the result, we hope, of finally getting the recognition that this branch of science deserves. Secretary Daniels is becoming aware of this, for he is recently reported to have said:

> The time was, that when we thought of battles, we thought of men. We were told by great leaders who had not looked into the future that the nations with the most men would win. Now it is not men, it is munitions and inventions, and to-morrow it will be neither—it will be chemistry.

The reason why the chemist has not received popular recognition like the physician, the engineer, the physicist or the geologist is that the activity of the chemist is outside the realm of comprehension of the average individual and he sees nothing imposing or spectacular with which to associate the chemist. He may admire the delicate shades of his wife's costume without considering what part the chemist had in producing them, and every day of his life he comes in contact with something or other upon which the chemist has left his finger prints.

The greatest problem confronting the profession to-day is that of getting recognition and support from the public, through its legislative bodies, but, as I mentioned before, the European war has done more than any one thing to secure the desired recognition.

The question has doubtless arisen in your minds, why it is that scientific research in Germany and other European countries occupies a higher plane than in America. To me the reason is obvious, and it is this: In Germany there is popular recognition for the research man. Everybody knows his worth to the state and to civilization. The manufacturer is especially appreciative of his work and is glad to cooperate even to his own disadvantage and loss in trying out certain processes or marketing given chemical substances whose demand may be very limited. Four out of five such ventures may be a loss to the manufacturer, but the fifth proves such a success that it overbalances the other four, and therefore if the manufacturer had not accredited the research work of the one who made the propositions, not one of the ventures would have been tried. This popular confidence in the value of chemical research has led to al-

most complete autonomy in the departments concerned.

In Germany the chief chemist is his own boss. He engages his assistants, fixes their compensation, engages and discharges janitors and laboratory helpers. He makes changes in the building and the laboratory with but nominal supervision. He apportions his funds according to his own ideas and is virtually his own administrator.

What the research man in this country needs more than anything else in order to make his work efficient, is freedom from restraint and petty annoyances. He should be made to feel that he has at least a part in the general organization and progress of the institution. Oftentimes he feels, and with a considerable degree of justification, that his department exists only by the gracious magnanimity of the administrators, whose knowledge of his work may be very limited.

Professor W. H. Walker at a joint meeting of three chemical societies in New York last winter made the following statement:

> My plea at this time is not so much for greater generosity on the part of the employer in matters of laboratory facilities, special equipment or a good library, however important these are, but rather for a larger appreciation of the conditions which make for ultimate success in research work.

In the same vein, Professor Arthur D. Little, speaking before the United States Chamber of Commerce, says:

> The plain underlying reason why we have been unable during thirty years of tariff protection to develop in this country an independent and self-contained coal tar color industry while during the same period the Germans have magnificently succeeded is to be found in the failure of our manufacturers and capitalists to realize the creative power and earning capacity of industrial research. This power and this capacity have been recognized by Germany and on them as corner stones her industries are based.

Aside from the question of recognition and support for the research man, another factor enters in, upon which the effectiveness of his work largely depends, and that factor is the time allotted to his work.

In this country there are very few independent research institutions and for that reason the major portion of scientific research is carried out in the universities and agricultural experiment stations. Everybody recognizes that teaching and research should go hand in hand and that no university professor fulfils his obligations unless he is doing some original investigation tending to advance human knowledge. This is all well and good, but are the colleges and smaller universities of the country allowing sufficient time to their professors for such work? How much creditable research could a professor carry out in the course of a year who is obliged to teach twelve to eighteen hours per week with an additional twelve or more hours in the preparation for his work? Young, enthusiastic professors have tried it over and over again, but with the same result—a stupendous failure—as far as the research goes.

The professor who has spent his energies in the classroom during the day is in no way fitted to continue his research problem in the evening, as many of them do. A neglect to observe the proper requirements for rest and relaxation will immediately tell upon the quality as well as the quantity of work produced. Consequently the college or small university can never hope to produce but an insignificant amount of research work, and this fact is recognized by President Woodward, of the Carnegie Institution at Washington, and by other administrators of research funds. It is very rare that a college professor gets a grant from such a fund, and for the very reason mentioned above.

The productive research workers in the country to-day are those who are devoting their whole time or practically their whole

time to that work. As a rule, the head professors in the larger universities are not giving more than one to five hours of lectures during the week, the rest of their time being devoted to research, while a large number of them have one or two private research assistants besides the candidates for degrees doing research work. The same is true in the European universities.

There are many other activities besides teaching that may seriously interfere with a man's productive capacity in research. The public demand for something spectacular that may be flaunted in the daily press sometimes prevails upon the scientist to forsake modest but meritorious investigation. The bid for popularity may even carry a man so far away from his department that no time at all remains for research. Furthermore, numerous cases are on record where good research men have been spoiled by promotions to official positions, so that their energies become dissipated in a mass of official detail instead of concentrated upon some one problem for solution.

Professor W. E. Castle in speaking of research establishments and the universities says:

> The attempt to combine teaching with research has another indirect but evil consequence. The periods which the professor can himself devote to research are intermittent and fragmentary. This affects disadvantageously the topics selected for investigation. They too must be minor and fragmentary. Great fundamental questions requiring long continued and uninterrupted investigation can not be attacked with any hope of success by one who has only an occasional day or a summer vacation to devote to research.

Also quoting a paragraph from Professor Woodward's report of the Carnegie Institution at Washington for last year. As regards the conditions favorable to research he says

> that fruitful research entails, in general, prolonged and arduous, if not exhaustive labor for which all of the investigator's time is none too much. Little productive work in this line may be expected from those who are absorbingly preoccupied with other affairs. Herein, as well as in other vocations, it is difficult to serve two or more exacting masters.

Another serious impediment to scientific research may be found in a too perfect organization for the handling of routine affairs connected with such work. In common parlance this perfect organization has been nicknamed "red tape." Now it sometimes happens that the red tape reels off smoothly and rapidly, but dare I say that more often it is thrown into kinks and snarls when the reeling stops. The phenomenon has doubtless been experienced to a greater or less degree by every one, but to conjure up pleasant memories, let me hypothesize as follows: *A* is a research chemist. He has discovered a new chemical compound which is rather unstable. He requires a certain chemical that will combine with the new compound and render it stable so that it can be investigated further. The requisition for the purchase of the chemical goes to *B*-check, then to *C*-check, then to *D*-check and finally to *E*-check, whereupon the chemical is ordered and within a short time delivered to *A*, greatly to his delight.

Next let us suppose that *A* is a research biologist who has just discovered a new form of marine life. He makes out a requisition for the purchase of a suitable stain or preservative and sends it to *B*. He learns, however, that *B* has gone fishing and the requisition rests. *B* returns in the course of time, checks the document and sends it to *C*. *C* has been unavoidably called away by the death of a close relative and the requisition is deposited to bide its time. Once released and checked by *C*, it is also checked at *D*, but for a good and valid reason is pigeon-holed at *E* for a few

days. The order finally goes, but when the material arrives the little stranger for whom it was intended has been dead and buried eight weeks and the discoverer *A*, whose fame might have been noised abroad in this connection, goes down to his grave untoasted, unhonored and unsung.

Any system, however perfect, that fails to provide for an emergency is worse than no system at all. As soon as a research man becomes tied down by arbitrary rules, whether they be called systems, organizations or what not, that soon his creative powers and effectiveness will be diminished. In this connection I perhaps could do no better in emphasizing my conviction than to quote a paragraph or two from Professor R. S. Lillie's Founder's Day Address at Clark University last winter.

When we look at our universities we are impressed with certain obvious peculiarities—their size, their wealth, the variety and complexity of their activities and of their organization. We may agree that size and wealth with the resources that they bring are all very well—in themselves desirable—but complexity of organization, and the practises and tendencies that go with it? Are these conducive to the intellectual life? This, in my opinion, is the critical question. So far from our taking this for granted there is good reason to believe that beyond a certain limit dependence on system and organization in institutions of learning is directly injurious to good work, and this for the simple reason that it makes for the stereotyping of activities, and hence interferes with freedom and its expression, which is originality. Such restriction, in fact, is the general purpose of organization: it aims at diminishing variation from an accepted norm. Now the more stereotyped certain things are the better; thus a railway service or a department store can not be too regular and dependable; but if our aim is not simply to repeat things that have already been done, but to discover new truth, the conditions that surround us, as well as our own temper of mind, should so far as possible encourage independent activity, and not simply that carried out in accordance with a program. In brief, purely routine activities should be subordinated in an institution of higher learning: all needless machinery should be disposed of, and the rest should be relegated to its proper place. This is a practical suggestion, and it is one of the first that I should make.

Lastly, I would like to consider a little more in detail the status of the research work in our agricultural experiment stations. Scientific work is sometimes very incorrectly and superficially judged by individuals or small groups of individuals. A meritorious piece of work may not receive immediate recognition, but will hibernate in the archives of some musty library for decades before it bounces forth in its full splendor. Nevertheless its status will soon be known, after having received due consideration by the scientists of the world.

From time to time various attempts are made to segregate and classify worthy and illustrious individuals in science, and it would be interesting to see what place the experiment station worker occupies in such segregations. From Professor Pickering's tabulation of eminent scientists (*The Popular Science Monthly*, February, 1915), it will be seen, that among the ten Americans who have been accorded the distinction of being elected foreign associates of two or more of the leading scientific societies of the world, there is no one who has been connected with an agricultural experiment station, but they are all research men who have devoted little or no time to teaching. It also appears that Norway and Sweden, with a combined population of less than eight million have produced nine scientists of the same distinction.

The Nobel Institute at Stockholm, Sweden, awards five prizes each year, three of which are for the most meritorious accomplishments in physics, chemistry and medicine. Among the forty or more who have received this recognition are two Americans, eminent research men, but neither of whom is a station man, and not

even a chemist. It should be said that only the chemists of the experiment stations would be eligible to these awards, but there are several hundred of them and a large number have now had ample time in which to establish the character of their work.

In this connection I wish to state, very emphatically, that I am not decrying all the scientific work of the stations. By no means. A great deal of it is of a high character and is becoming more and more so as time goes on. Some stations have manifested a marked improvement in the character of their work during the past four or five years, and it is to be hoped that our station will not be obliged to take a backward step. Why do you suppose our men of science in the agricultural experiment stations are not found among the fellows of the Royal Society of London or among the foreign members of the French Academy? Why is it that they are not in evidence in the Berlin Academy, or even in our own National Academy of Sciences?

The twenty-two men recently chosen on the Naval Advisory Board are essentially research men and inventors. The two men chosen by the American Chemical Society, Dr. Whitney and Dr. Baekeland are research chemists in the true sense of the word. It is obvious that the experiment station men have not yet risen to the rank entitling them to places in the notable segregations of the truly scientific men of the world. Exceptions of course must be made to the representations in "Who's Who?" and to pay-as-you-enter classifications.

There are now nearly seventeen hundred agricultural experiment-station workers in this country and their combined productivity is something enormous when quantity is considered. Their opportunities for producing genuine and fundamental research could be as great as those of the professors of the larger universities if they had the training and the concept of the deeper problems of nature and were not led astray by the tyro and dilettante who is invariably imbued with the get-rich-quick idea, although he uses the much more elegant and suggestive term "practical." The cry in the experiment stations is for something practical, not realizing that the most fundamental is the most practical in the long run.

Our stations are organized to benefit the farmer, but when we accord to the farmer the privilege of deciding what work is practical and what is not, and what problems should be undertaken and what ones should be dropped, we are committing a grave error. The pedestrian journeying along the road may properly express his opinion about the desirability of having a bridge built to span the stream but when he proposes to direct the engineer regarding the location or type of the bridge or even regarding the feasibility of having a bridge built at all, he is overstepping his bounds; but no more so than when the farmer frames the problem for the research man. Valuable suggestions regarding desired results may often be obtained from the layman, but the trained expert is the best judge whether or not the "practical" problem is practicable.

The fact that the experiment-station worker must cater to public sentiment is one of the main reasons for his failure to occupy the respected places in truly scientific circles. It is to be hoped that the farmer will acquire a greater degree of tolerance for the technical, the obscure and to him unintelligible, and when that day comes we hope that this admirable branch of science will be elevated to its proper place. Then, truly scientific men who have had the misfortune to become enmeshed in the agricultural experiment stations will

not need to be buried alive, but will stand an equal chance with their fellows in other departments of science.

The matter of training for research work has only been alluded to indirectly but I have assumed as self-evident that only the best kind of training suffices for the highest type of research. Charlatans are found in every department of science and administrators of research funds must be on their guard against their plausible but evanescent schemes. Men of this class are usually much better talkers than experimenters.

Having pointed out some of the weaknesses in research work of our agricultural experiment stations, I would like to offer a suggestion that might prove beneficial. In my opinion there is not enough expert counsel and supervision over the departmental work that is being carried on. The work in almost every field of industry is inspected and criticized, some time or other by experts efficiently trained in the departments concerned. No large engineering or construction work could proceed efficiently without expert supervision and oftentimes outside counsel and advice, and I venture to say that if this were secured for the departments of the agricultural experiment stations it would do much toward improving the character of the work and giving directors more reliable information regarding the work of their departments, in which they themselves are untrained.

It seems to me that a chemist should inspect the chemical work of a station, a botanist the botanical work, an entomologist the entomological work, and so on. The cost of inspection would thus be considerably higher than at present, but I am inclined to believe that the value to the stations would greatly overbalance this and bring departmental work up to the standard required of them. Incidentally, favorable reports from technically trained inspectors would greatly influence popular opinion concerning a given piece of work and act as a bulwark to the director in meeting outside criticism. Such inspections would also materially aid in ridding the stations of the superannuated, derelicts and driftwood which are such impediments to progress.

Another suggestion I should make is that research projects of whatever nature should be passed upon or suggested by a committee of men technically trained in the fields in which the projects are to be launched. It is not to be expected that directors and officials at Washington are competent to judge of the feasibility of a given project for research, especially when it lies outside the circumference of their own training. In my opinion such a system would result in much good to the stations and to the people at large.

To sum up, let me say that the scientific research of this country and especially of the agricultural experiment stations, has not yet reached the high standard that is possible of attainment, and that the reasons would seem to be the following: a popular disregard or lack of appreciation for research; the encroachment upon the time of the research man by teaching, outside and official work; annoyances and distractions through the business and administrative organizations; the popular demand for practical and control work rather than for the fundamentally scientific.

These unfavorable conditions could easily be remedied; and then by requiring of the research man a more thorough training, and giving him some reliable counsel, the character of his research work would unquestionably advance.

Let me close by quoting Director A. C. True's advice, which as seed, I hope, will not fall by the way side, or among thorns, or upon stony ground, but in rich black

loam where it may grow and bring forth the desired harvest. He says:

Words of friendly criticism may be as silver, but far better are golden words of encouragement.

C. Alfred Jacobson

University of Nevada

THE U. S. FISHERIES BIOLOGICAL STATION AT WOODS HOLE

The laboratory of the U. S. Fisheries Biological Station at Woods Hole, Mass., was open from June 21 to September 15 during the past summer. P. H. Mitchell, of Brown University, was director. Investigators appointed by the Bureau of Fisheries conducted the following researches bearing on the economics of the fishing industries: I. A. Field, of Clark College, the anatomy of the circulatory and nervous systems and the embryology of the edible muscle; C. W. Hahn, of the High School of Commerce, the mode of infection by, and the life history of several parasites of herring, alewives and some other food fishes; A. Kuntz, of the Washington University Medical School, with L. Radcliffe, of the U. S. Bureau of Fisheries, the identification and study of the embryological and larval stages of twelve species of common fishes; E. Linton, of Washington and Jefferson College, investigations of various fish parasites with special study of helminth and nematode parasites of butter fish, also a study of the food of winter flounders; P. H. Mitchell and W. W. Browne, of the College of City of New York, nutrition of oysters with special reference to conditions of glycogen formation; S. Morgulis, of the College of Physicians and Surgeons, the digestive enzymes of Teleosts, the changes in weight and composition of starving lobsters, a critical analysis of Moore's investigations on the metabolism of marine organisms, and a colorimetric method for approximate oxygen determinations in sea-water; G. G. Scott, of the College of the City of New York, the oxygen consumption of developing fishes at various stages, the oxygen consumption of 42 marine forms for comparison of rates of metabolism, the efficiency of various means of aerating aquaria, conditions affecting the oxygen requirements of fishes, the oxygen consumption of regenerating tissues, and the dry method of shipping live fishes; A. Thomas, of Clark University, the toxic effect of heavy metals on fishes; G. F. White, of Clark University, methods of preparing dried dogfish for human food, the distribution of nitrogen in dog fish muscle, the phosphatides of dogfish egg-oil, the collagenous matter of dogfish skulls and of tilefish swim-bladders; W. W. Browne, of the College of the City of New York, the possibilities for fish to act as carriers of pollution bacteria and the time required to rid fish of such bacteria when put in unpolluted water; B. H. Gross, the conditions affecting the occurrence of color in "green oysters"; K. S. Rice, of Brown University, the behavior of oyster spat under artificial conditions, and the methods of ridding oysters of the colored copper-containing compound found in "green oysters."

Besides the work of employees of the bureau, a number of investigations were conducted by table applicants to whom the facilities of the laboratory were extended. Such researches were as follows: R. P. Bigelow, of the Massachusetts Institute of Technology, an examination and study of 27 species of Crustacea collected by the *Albatross* during the Philippine expedition; S. R. Clemence, of the American Museum of Natural History, a survey of the reptilian and batrachian fauna of the Elizabeth Island; G. A. MacCallum, observations on fish parasites; G. H. Parker, of Harvard University, a study of reflexes and other nerve reactions of Cœlenterates; A. C. Redfield, of Harvard University, the control of chromatophores in *Fundulus* embryos, in flounders and in horned toads; E. A. Redfield, of Harvard University, the movements of shell and mantle in Lammellibranchs and the relation of such movements to respiration; I. L. Shaw, studies of diatoms; J. M. Thorrington and F. P. Reagan, of Princeton University, the development of hybrids with especial reference to the vascular system; H. C. Tracy, of Marquette University, the relation of the swimbladder to the ear and the eighth nerve in *clupeidæ*; G. B. Wislocki, of Johns Hopkins University, the internal secretions of fishes.

THE COLUMBUS MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

The arrangements for the Columbus meeting of the American Association for the Advancement of Science are taking definite shape and a large attendance and an interesting program are certain.

The following affiliated societies have already indicated their intention of meeting at Columbus at the same time:

American Society of Naturalists.
American Society of Zoologists.
American Physical Society.
Botanical Society of America.
Botanists of the Central States.
American Phytopathological Society.
Entomological Society of America.
American Association of Economic Entomologists.
American Mathematical Society (Chicago Branch).
American Nature-Study Society.
American Microscopical Society.
Society for Horticultural Science.
Association of Official Seed Analysts of America.
American Federation of Teachers of the Mathematical and the Natural Sciences.
The School Garden Association of America.

Some slight conflict, owing to the fact that the committee, designated to take charge of the Second Pan-American Scientific Congress to be held in Washington, without consultation with the officers of the American Association for the Advancement of Science or, apparently, with other well-posted scientific men in this country, changed the date of the Congress from October, 1915, to December 27, 1915–January 8, 1916, thus occupying a large part of the time already set aside for the meetings of many national scientific organizations, nearly all of which are to meet elsewhere than in Washington.

The group of economic and historical societies have met this unfortunate situation by changing their plans to meet in Washington. Their sessions are to be held during the first week of the Congress. The American Association for the Advancement of Science and its affiliated societies, however, owing to the fact that the Congress is to be devoted very largely to economic subjects, have seen no reason to alter their plans and will carry forward the Columbus meeting which every indication shows will be eminently successful.

The authorities of the congress, however, are anxious to secure some degree of cooperation from the American Association for the Advancement of Science and its affiliated societies and have extended an invitation to these organizations to come to Washington at the conclusion of the Columbus meeting and attend the meetings of the second week of the congress (January 3–8, 1916). It has also been suggested by the assistant secretary general of the congress (Dr. G. L. Swiggett), that the association might to advantage hold an adjourned session of one day in Washington to indicate its desire to assist in welcoming the delegates from other American countries to the United States.

Whether this invitation will be accepted is a matter which can not well be decided until the Columbus meeting. That such a session of the association should be called an adjourned session from Columbus would, in a way, be discrediting the Columbus hosts of the association, since the coming meeting should be definitely known as the Columbus meeting and not as the Columbus-Washington meeting. It might, however, be arranged so that the American Association could hold a special session at Washington on some one of the dates indicated and which need not in any way detract from the success of the Columbus meeting or from the fact that the convocation week meeting of 1915–1916 shall go down to history as the Columbus meeting.

L. O. Howard,
Permanent Secretary

SCIENTIFIC NOTES AND NEWS

The spring meeting of the American Chemical Society for 1916 will be held in Urbana, Illinois, April 18 to 21, inclusive. At that time the new chemical laboratory of the University of Illinois, said to be the largest in the world, will be dedicated.

Mr. E. W. Swanton has been elected president of the British Mycological Society.

PROFESSOR EBERTH, formerly professor of pathologic anatomy in Halle, discoverer of the typhoid bacillus, celebrated his eightieth birthday on September 21.

THE officers elected by the Medical Research Club of the University of Illinois for the year 1915–16 are: Dr. J. J. Moore, president, and Dr. Roy L. Moody, secretary.

DR. THEODORE MORTENSEN, curator of the National Museum at Copenhagen, is in Los Angeles conducting scientific research as a guest of the biology department of the University of Southern California.

DR. DANIEL J. MCCARTHY, professor of medical jurisprudence in the University of Pennsylvania, has returned from the American Ambulance Hospital in Paris and will make a report on the influence of the war on the nervous system and mental future of the soldiers.

MARGARET HARWOOD (Radcliffe, '07), later at Harvard Observatory until June, 1912, and since then, by annual award, astronomical fellow of the Nantucket Maria Mitchell Association, has been appointed for an indefinite term fellow of the association and director of its observatory. This year, which is the "quadrennial" provided for in the fellowship, Miss Harwood is studying at the University of California. Her new year at the Nantucket Observatory will begin June 15, 1916. A five hundred dollar Maria Mitchell fellowship for research work at Harvard Observatory will be available for the three years 1916 to 1919.

PROFESSOR H. RIES, of the department of geology, of Cornell University, will give a course of ten lectures on economic geology, at Columbia University during the first term, in the absence of Professor J. F. Kemp, who is absent on leave.

AT the November meeting of the Central Association of Science and Mathematics Teachers, Professor L. C. Karpinsky, of the University of Michigan, will give a paper on the story of algebra. After this paper an hour will be devoted to the discussion of the place of the history of mathematics in elementary science.

PROFESSOR HEINRICH O. HOFMAN, acting head of the department of mining and metallurgy at the Massachusetts Institute of Technology, addressed on October 20 the Franklin Institute in Philadelphia on "The Metallurgy of Copper."

THE opening address at the college of medicine, University of Illinois, was delivered by Dr. Wm. H. Welker, assistant professor of physiological chemistry.

IN his annual report, President Charles F. Thwing, of Western Reserve University, pays tributes to Dr. Dudley P. Allen and Dr. Hunter H. Powell, referred to as having performed distinguished services as members of the faculty of the School of Medicine. President Thwing says:

Among the gifts included in the donation of $1,000,000 for the endowment of the School of Medicine was the sum of $40,000 given by members of this board with the request that this sum be used in some form to give aid to the work in which Dr. Powell was interested. I therefore venture to renew a recommendation made in a previous report that a fund be formally established to bear the name of Dr. Powell, of which the income shall be used for the support of the department to which he gave his life. To the $40,000 which should be thus set aside might fittingly be added at least $10,000. I also beg leave to express the hope that, in recognition of Dr. Allen's great service rendered to the cause of surgery in and through the School of Medicine, a special fund may be secured to bear his name, the income of which shall be used for research in the science of surgery, or for the support of its practise.

AT the meeting of the faculty of the Cornell University Medical College held at the College on Friday, October 15, 1915, the following memorial was read and adopted:

Austin Flint, M.D., LL.D., professor emeritus in the Cornell University Medical College, passed away September 22, 1915, in the eightieth year of his age. A student of Claude Bernard and of Robin, he early achieved distinction. Thus, in 1862, at the age of twenty-five, he discovered a substance in human feces which he called stercorin, recognizing it as a derivative of cholesterin. This discovery was awarded honorable mention by the Institute of France. It did not receive full recognition because of an unfavorable pronounce-

ment by Hoppe-Seyler. However, in 1896, stercorin was again discovered, this time by Bondzynski, and given the name of koprosterin. To Flint, however, working with older, cruder methods, belongs the credit of having first isolated the substance in pure crystalline form. Austin Flint was one of the greatest teachers of the old school of American medicine. A forceful orator and skilled experimentalist, he was the first in this country to expound the doctrines of the French school of physiology which in his early life was at the height of its renown. Dr. Flint took pride in being of the fifth generation of noted physicians, his great-grandfather and his father having borne the name Austin Flint, a name which outlives him in a surviving son. We, the faculty of Cornell University Medical College, with which Dr. Flint was associated during ten years, hereby record our appreciation of this life and beg to tender our sympathies to his family.

Augustus Jay Du Bois, for thirty years professor of civil engineering in the Sheffield Scientific School, Yale University, died at his home in New Haven, on October 19, at the age of sixty-six years.

The Rev. Father Charles M. Charroppin, S.J., an astronomer, and formerly head of the department of science of St. Louis University, died at St. Charles, Mo., on October 17.

Rev. Michael J. Tully, S.J., died on October 20, at the age of thirty-nine years, at Fordham University, New York. Father Tully had occupied the chair of chemistry in Boston College, at Holy Cross, St. Francis Xavier and Fordham University.

Edward A. Minchin, F.R.S., professor of protozoology in the University of London, has died at the age of forty-nine years.

Professor C. A. Ewald, of Berlin, distinguished for his work on diseases of the stomach, for thirty years editor of the *Berliner klinische Wochenschrift,* died on September 20, in his seventieth year.

At the recent meeting in Manchester, as we learn from *Nature,* the general committee of the British Association unanimously adopted the following resolution, which has been forwarded to the Prime Minister, the Chancellor of the Exchequer and the Presidents of the Board of Education and of Agriculture and Fisheries: "That the British Association for the Advancement of Science, believing that the higher education of the nation is of supreme importance in the present crisis of our history, trusts that his Majesty's government will, by continuing its financial support, maintain the efficiency of teaching and research in the universities and university colleges of the United Kingdom."

The geological department of Yale University has since 1871 graduated 50 men and 2 women with the degree of doctor of philosophy. Of these 50 are living, and all but 4 are following geology as a profession. Up to 1890 the degree was conferred upon 7, during the decade 1890–1900 upon 8, from 1900 to 1910 upon 22, and since then upon 15. Of those following the profession, 15 are professors and 6 are assistant professors or instructors in universities, 11 are geologists on the Geological Survey of Canada and 5 on the United States Geological Survey, 5 are state geologists, and 3 are curators of geological collections in public museums.

UNIVERSITY AND EDUCATIONAL NEWS

The sum of about $400,000 has been subscribed in the University of Michigan alumni campaign for $1,000,000 with which to build and endow a home for the Michigan Union, as a memorial to Dr. James B. Angell, president emeritus.

Delaware College, at Newark, has received a gift of $500,000, from a donor whose name is withheld, for the construction and maintenance of buildings.

The contracts have been awarded for the erection of a new biological laboratory at the University of Nebraska to house the departments of botany and zoology. The building will be a memorial to the late Charles E. Bessey and will be known as "Bessey Hall." The main building will consist of three floors and a basement fifty by two hundred and thirty-five feet with a short wing at each end. Greenhouses and vivaria will be connected with the building.

THE formal opening of the new chemistry building of the University of South Dakota, Vermillion, was celebrated on October 12 and 13. Professor Louis Kahlenberg, of the University of Wisconsin, delivered the address on that occasion. His subject was "The Chemical Aspects of Osmosis." He also spoke at convocation of the university on the subject "Important Factors in choosing Life's Work."

THE *Journal* of the American Medical Association states that an important branch of the department of pathology in the Johns Hopkins University, to be devoted entirely to research work, will be opened within the next six weeks in the pathologic building, after Dr. William H. Welch returns from China. The rooms to be occupied in the new work have been equipped with scientific appliances and instruments costing several thousand dollars. A fund aggregating $22,000 has been raised for supporting the work for three years. In the absence of Dr. Welch, Dr. Milton C. Winternitz, his first assistant, has been directing the work.

PROFESSOR ALFRED H. LLOYD, of the department of philosophy, has been appointed to succeed the late Professor Karl E. Guthe as dean of the University of Michigan Graduate School.

DR. WILLIAM G. SPILLER has been elected professor of neurology in the medical school of the University of Pennsylvania, filling the vacancy made by the resignation of Dr. Charles K. Mills. Dr. Mills has been elected professor emeritus.

DR. JOHN C. DONALDSON, recently from the Johns Hopkins Medical School and the Phipps Psychiatric Institute, has been appointed instructor in anatomy at the University of Cincinnati. Dr. Edward F. Malone has been advanced to be associate professor of anatomy in the same university.

DR. WESLEY M. BALDWIN has resigned as assistant professor of anatomy from the Cornell University Medical College to accept the position of professor of anatomy at the Albany Medical College. Dr. Charles V. Morrill has been appointed instructor in anatomy and Dr. Robert Chambers, assistant in anatomy at the Cornell University Medical College.

AT the Stevens Institute of Technology Mr. Samuel H. Lott, instructor in descriptive geometry and mechanical drawing has been appointed assistant professor. Mr. L. C. F. Horle, assistant in physics, and Mr. Lewis A. Belding, assistant in electrical engineering, have been made instructors.

DR. RICHARD M. HOLMAN, who received the degree of doctor of philosophy at the University of California in May, has been elected a member of the staff of botany of the University of Michigan. Before attending the University of California Dr. Holman spent two years in study at Leipzig with Dr. Pfeffer. Previous to that time and after graduating from Leland Stanford Junior University he was a member of the faculty of the University of the Philippines.

DR. CHAS. O. CHAMBERS, formerly of Peabody College, Nashville, Tenn., has taken up his work as head of the department of botany and station botanist at the Oklahoma College.

THOMAS L. PATTERSON, for the past three years associate professor of biology and physiology in the University of Maryland, school of medicine, has assumed the duties of assistant professor of physiology in the faculty of medicine of Queen's University, Kingston, Canada.

DISCUSSION AND CORRESPONDENCE

INTERNATIONAL RULES OF ZOOLOGICAL NOMENCLATURE

TO THE EDITOR OF SCIENCE: Frequent requests come to me for an English edition of the International Rules of Zoological Nomenclature, as emended to date.

The Rules in question are published in the following places:

English: Proceedings of the Ninth International Congress on Zoology, held at Monaco, March, 1913, published by the Imprimerie Oberthur, Rennes, France, 1914.

French: By Maurice Cossmann (*Revue Critique de Paléozoologie*), 110 Faubourg Poissonnière, Paris, France, 1914. Price 5 francs.

Italian: Regole Internationali della Nomenclatura Zoologica. Translated by Professor F. S. Monticelli, and published by Luigi Niccolai, Florence, Italy, 1914. Price 5 lira.

Several unsuccessful attempts have been made to obtain a reprint in English, but the outlook for sale has been so indefinite, or other points have arisen, so that publishers have not been inclined to undertake the work as a business venture. Finally, in order to make it possible for zoologists to obtain a copy of the rules to date, arrangements have been made for a mimeographed edition of all the rules, with cross references to the opinions, and with an appendix containing summaries of the opinions No. 1 to No. 56.

This mimeographed edition is issued by T. O. Smallwood, 3216 N Street, Washington, D. C., price per copy 50 cents, plus 10 cents postage.

C. W. Stiles,
Secretary to Commission

GERMINATING POLLEN

To the Editor of Science: In the past, a number of requests have come in asking for the method employed by this station in determining the germinability of pollen of deciduous tree- and bush-fruits. Others who are interested in this matter will find the following method useful.

Mature pollen, either directly from the anther, or that which previously has been collected and stored, is used. Van Tieghem cells or 10 × 20 mm. moist chamber rings are fastened to ordinary microscope object slides by means of soft paraffin, employing as little as possible of the latter, and yet secure a waterproof joint. Put one or two drops of water into the cell and at two or three points about the upper edge place tiny drops of vaseline. This is better than the smearing of the entire circumference, since it serves as well to hold the cover in place and does not exclude air. Next place a small drop of the germinating medium in the center of a cover glass having a diameter somewhat greater than that of the cell. We employ 22 mm. squares. If the medium tends to spread over the glass, spread very thinly with vaseline and wipe with a dry cloth until the vaseline apparently has been removed. Sow the pollen grains evenly and sparingly over the surface of the drop by means of a needle or camel's-hair brush. If the latter is used hold it above the drop and tap lightly to scatter the pollen. Pollen may be used directly from the expanded anther by touching the latter to the germinating medium. Quickly invert the cover, place over the cell, and press it down gently, having the drop of germinating medium approximately in the center. A temperature of 22° to 25° Centigrade is best.

The germinating medium is the most important item. It may be necessary to vary its composition for the several varieties of fruits or even for the same variety, depending upon prevailing environmental conditions under which the pollen developed or has been stored.

Sometimes a 3 per cent. to 10 per cent. aqueous solution of cane sugar is entirely satisfactory. If there is considerable bursting of the pollen grains soon after sowing, increase the percentage of sugar; decrease the amount if plasmolysis takes place. Solutions should be made up fresh each day. Frequently it has been impossible to secure the optimum germination from simple sugar solutions. Most of the difficulties were avoided and excellent results obtained, when from ½ per cent. to 2 per cent. gelatin was added to the medium. The gelatine is first made up as a 4 per cent. or 8 per cent. solution. Soak the gelatin in cold water, then dissolve with the least possible heating. This solution, without sugar, will remain fit for use for several days. From this stock solution of gelatin, dilutions are readily obtained. In making up the germinating medium the diluted gelatin solution is reckoned as water and the cane sugar added directly to it. While not absolutely exact, perhaps, the method is sufficiently accurate. Thus, for a 4 per cent. solution of sugar in ½ per cent. gelatin, add one gram cane sugar to 24 c.c. of a ½ per cent. gelatin solution. Combinations of 3 per cent. to 12 per cent. cane sugar in ½ per cent. to 2 per cent. gelatin have proved very satisfactory. No definite combi-

nation can be recommended for any particular variety.

While it is generally possible to secure a higher percentage germination in the gelatin-sugar solutions than in the simple sugar solution, growth of the pollen tube is often less rapid, especially when the larger amounts of gelatin are used. This is frequently an advantage if large numbers of samples are being tested, since long, interlacing tubes make counting difficult.

E. J. Kraus

Oregon Agricultural Experiment Station

SCIENTIFIC BOOKS

Economic Geography. By John McFarlane, lecturer in geography in the University of Manchester. The Macmillan Company. 8vo. Pp. 560. $2.25.

The work is based on the principle of natural regions. It is recognized, however, that political conditions control economic development so largely that the boundaries of countries, whether natural or arbitrary, must figure in the reckoning. Also true geographic units may be closely linked into a group dominated by one or more geographic factors.

Preceding the geography of continents and countries are three chapters on physical conditions of economic activity, climate and vegetation. These chapters occupy but 26 pages and it may be questioned whether so brief and general a statement is useful as an introduction to the main treatment. The author recognizes that the economic geographer relies on the geologist, meteorologist, botanist, etc., for the data which he correlates, and it would, in the reviewer's judgment, be as well to leave the case thus; for, to take an example, a non-geologist could not derive much help from the author's two-page account of rocks and geological periods, or from one page on the principles of geomorphology, or the like brief discussions of winds, ocean currents and the distribution of plants. Should we not frankly concede that this branch of geography is an advanced phase to be based on previous training in physical and biological geography?

The proportioning of space in the regional treatment is fairly balanced considering that the text is no doubt expected to be used mainly by British students. This fact would justify 38 pages for the United Kingdom and 34 for the United States. Indeed most American texts are more one-sided than this. On the same basis we can not criticize the assignment of more space to India and Ceylon than to Germany, or giving two thirds as much space to Canada as to the United States. Our author used the term *economic* as designating the phase of anthropogeography here treated. It is not easy to see that the subject-matter differs in general scope from the volume by Mr. Chisholm, who although deeply versed in economic conditions, calls his handbook commercial geography. So, it would seem, we are still using these terms interchangeably. It is to be hoped that we may be able in time to arrive at more specific terminology.

As for the body of the work, we find sound, clearly expressed and informing accounts of the physical conditions, products and trade of the various countries, the work of a thorough and conscientious geographer. The illustrations are confined to maps, eighteen in number, mainly devoted to rainfall and the delineation of natural regions. Possibly the author's plan was deliberate, not to emphasize transportation either by map or text, and thus to justify somewhat the term economic. The chapter on the United States has been prepared with evident care. The map of natural regions conveys some misapprehensions which indeed a generalized map could not avoid. Some misleading boundaries, however, are qualified by statements in the text. Still it is not quite appropriate, as seen by an American geographer, to include the lake plains of New York and the coastal plain of New Jersey in a "Middle Appalachian Region."

The volume takes a good place among the few comprehensive manuals in English dealing with this aspect of geography.

A. P. Brigham

IO AND ITS ENVIRONMENT

The manuscript of Dr. Chas. C. Adams's paper on "The Variations and Ecological Distribution of the Snails of the Genus *Io*" was

completed more than three years ago, but has only recently been published.[1] However, little has appeared in the interim which bears directly on the subject and the author has not found it necessary to alter his original discussion.

Io is a small genus of large aquatic snails confined to the Tennessee River system and mainly to that part which lies upstream from Chattanooga. On looking over a representative collection of these shells one is immediately impressed with the great variation in their spinosity; some are absolutely smooth, and there is every intergrade from these to shells on which the spines are nearly or quite as long as the radius of the whorl. In addition there is a considerable range in the variates which one is tempted to call "ordinary"—general size of adults, globosity or shell index, color, and so forth. Adams examined chiefly the variation in shell diameter, globosity and spinosity. This he did by making careful measurements of large collections from stations throughout the range of the genus. Data for variation curves are given not only in absolute frequencies, but in "frequencies reduced to thousands" and in plotted curves. No data are given for studying correlated variation, nor has the variability of the characters been analyzed by use of the statistical methods now familiar, by reputation at least, to all students of evolution. There is probably ample justification for this omission in the fact that it is very difficult to be sure that a series is homogeneous with respect to age. At any rate, a large amount of data is offered to any enterprising biometrician who may care to tackle it, and the author seems to have gotten along fairly well, as far as he has gone, without a thorough mathematical analysis of the variability.

An inspection of the curves shows that there is a progressive change from the headwaters of the various branches of the river system downstream as follows: "From a greater diameter of the shell to less; from a high degree of globosity to one of a less degree; from a spineless to relatively long spines; from a narrow space between the spines to a wider space; and from a relatively low spine index to one of a high degree. The change from the smooth to the spinose shell is relatively abrupt, as shown by the modes, but there is a perfect series of individual intergradations." The fact that in the Holston River near Rogersville there are smooth shells where one would expect from the foregoing to find spiny ones will be referred to later.

The generally accepted belief among paleontologists concerning the phylogenetic development of spines is quoted from Beecher[2] as follows:

> The first species [of a group of animals] are small and unornamented. They increase in size, complexity and diversity, until the culmination, when most of the spinose forms begin to appear. During the decline extravagant types are apt to develop, and if the end is not yet reached, the group is continued in the small and unspecialized species which did not partake of the general tendency to spinose growth.

The author considers the possible effects of direct environmental action, hybridization and other factors as explaining the distribution of the various shell types, but there are not sufficient data at hand to reach a satisfactory conclusion. Experimental work was started but dropped because of lack of facilities. However, the orthogenetic "law of ornamentation" just quoted, taken in connection with stream history and the mixing of strains, seems to explain many of the facts.

What might be called phylogenetically young streams are rapid. In such the phylogenetically young *Io* developed, small and smooth. As time went on the streams became older, less rapid or with rapids further apart at the place where *Io* started, but the streams continued ever young at their heads where they worked back into the land mass. *Io* became phylogenetically older at its place of origin and progressed in its orthogenetic course toward

[1] Memoirs of the National Academy of Sciences, Vol. XII., Part II., Second Memoir, 1915, pp. 1–184, 61 plates.

[2] "The Origin and Significance of Spines. A Study in Evolution," Yale Bicentennial Publications, 1901, pp. 1–105.

large and spiny shells. The original type of snails followed the "young" part of the stream backward and thus there tends to be a continuous series of forms as one follows the stream. One has but to start at the headwaters and go down stream in order to see unfolded the history of both stream and shell. By the time Chattanooga is reached the stream has gotten too old, physiographically, for the snails, too deep and possibly too contaminated.

The finding of smooth shells near Rogersville in the Holston River and of spiny shells above them really fits in with this idea if we look more closely into the history of this part of the river system, for here there has been stream piracy. A young stream containing smooth shells has probably worked over into the valley of an old stream, containing spiny shells above the point of intersection, and the result is the Holston River as we now know it.

To be sure, we should like to have an explanation of the causes underlying the law of ornamentation, and also of the reason why the successively spinier snails seem to have forced their smoother relatives to migrate with the growth of the stream or to have been prevented from working up to the headwaters themselves, but we can not expect an explanation of the ultimate and Dr. Adams is to be congratulated on the progress which this paper makes in the, as yet, largely unexplored field of animal ecology.

Frank E. Lutz

THE PLIOCENE FLORAS OF HOLLAND

The study of the more immediate progenitors of the existing flora, the vast changes in distribution, and the extensive extinctions and migrations that resulted from the glaciation of the Pleistocene, as well as the evolution of recent herbaceous forms that followed in its wake, constitutes a field of endeavor that not only appeals to the imagination, but one that offers much to botany and much that is useful in reconstructing the geography, climate and history of the late Tertiary and the Quaternary. For thirty-odd years Clement Reid has been engaged in the study of the Pliocene and Pleistocene deposits of Britain and their contained floras. Some years ago with the assistance of Eleanor M. Reid he described the upper Pliocene flora of Tegelen in Holland,[1] and recently these authors have published the results of an elaborate study of similar remains from a slightly older horizon collected from the brick-clays of Reuver, Swalmen and Brunssum along the Dutch-Prussian border.[2]

This study is not only a significant contribution to the botany of the Pliocene, but it furnishes data of great importance to historical geology. With the shallowing of the Diestian or perhaps the Scaldisian sea, the delta of the combined Rhine and Meuse extended a long distance to the northwest as it did at several subsequent times during its history, as is proven by the Rhine gravels in the Cromer beds of Norfolk, and by the mammalian fauna and peat of the Dogger Bank. Remains of the middle Pliocene high-level terraces, much faulted, occur to the south and east of the Limburg plain, where the brick clays are exposed in the scarp facing that plain. The materials were collected by W. Jongmans of Leiden and P. Tesch of the Geological Institute for the exploration of the Netherlands. The Reids expended all of their efforts on the remains of fruits and seeds which they laboriously picked out of the washings of an enormous amount of material.

In the less lignitic loams lying immediately below the horizon reported upon, impressions of leaves occur and these were studied some

[1] Reid, C., and E. M., "The Fossil Flora of Tegelen-sur-Meuse, near Venloo, in the Province of Limburg," *Verhandl. Kon. Akad. Wetensch.* (Tweede Sectie), Deel XIII., No. 6, 1907; "On *Dulichium vespiforme* sp. nov. from the Brick-earth of Tegelen," *Verslag. Kon. Akad. Wetensch. Amsterdam,* 1908, p. 898; "A Further Investigation of the Pliocene Flora of Tegelen," *Ibidem,* 1910, pp. 192–199.

[2] Reid, C., and E. M., "Preliminary Note on the Fossil Plants from Reuver, Brunssum and Swalmen," *Tijdsch. Kon. Ned. Aardrijks. Genootschap,* 2e ser., Deel XXVIII., afl. 4, 1911, pp. 645–647; "The Pliocene Floras of the Dutch-Prussian Border," *Mededeelingen Rijksopsporing van Delfstoffen,* No. 6, The Hague, 1915, 178 pp., 4 tf., 20 pls.

years ago by L. Laurent of Marseilles.[3] His determination included ten dicotyledons and one conifer and indicated a similar age to that indicated by the overlying seed and fruit flora. The latter is remarkable in including nearly three hundred species, of which the botanical position of about 77 per cent. is determined with considerable certainty. This flora is shown to present a striking similarity to the living flora of the uplands of western China and to its more or less allied geographical provinces, *i. e.*, Japan, the Himalayas, eastern Tibet and the Malay Peninsula. A more remote relationship is shown with the existing flora of Europe or the Caucasus, and a still more remote relationship with the existing flora of North America.

This oriental character is shown by the presence in Limburg of forms like *Gnetum scandens, Zelkowa keaki, Pyrularia edulis, Magnolia kobus, Prunus maximoviczii, Stewartia pseudo-camellia*, etc., no longer natives of Europe, as well as by representatives of genera such as *Meliosma, Actinidia, Corylopsis, Camptotheca*, etc., not found in the existing European flora, but represented by closely allied species in China. Even when the genus is still a member of the European flora, the fossil species appears to be closer to the existing Asiatic rather than the existing European representative, as, for example, in the genera *Pterocarya, Styrax, Betula, Cornus, Clematis, Eupatorium*, etc. There are, however, among the fossils a number of large-seeded forms that are still represented in the flora of Europe, among which may be mentioned *Picea excelsa, Quercus robur, Carpinus betulus, Corylus avellana, Prunus speciosa, Ilex aquifolium, Vitis vinifera* and *Fagus* cf. *silvatica*.

The Reuverian flora, as it has been called, appears to indicate a climate about like that of southern France of the present time, but with a more abundant rainfall. It was richer in species than the present flora of Central Europe and the number of arborescent forms was greater, both relatively and absolutely, comprising fifty per cent. of the determined forms. This and other conclusions which are deduced from the present study are well known to paleobotanists, but seem to require constant reiteration to get a hearing with botanists or geologists.

The authors' explanation of events is in brief an immigration of this rich and varied warm temperate flora into the Dutch region [a survival in this region as a part of the rich and more or less cosmopolitan flora of the earlier Tertiary is probably a better way of stating the case], where with the progressive lowering of temperatures in the late Pliocene as is indicated by the floras of Tegelen near Venloo, Wylerberg near Nijmwegen and the Cromer Forest bed, it found its retreat to the southward cut off by mountains, seas or deserts, from the Pyrenees on the west eastward all of the way to Tibet, so that all but a few forms like *Quercus robur, Corylus avellana* and *Picea excelsa* were subsequently exterminated. Even those forms that succeeded in reaching the shores of the Mediterranean seem to have found themselves in a climate that was too dry.

Compared with Europe both North America and eastern Asia afforded better facilities for a continuous movement of plants to the southward and back—North America with its mountains trending north and south, with the broad valley of the Mississippi and the well-watered Atlantic coastal plain—eastern Asia with the coastal plain of China and the great river-valley systems of that country. Recolonization from the southward in post-glacial Europe was a slow process and these are two of the reasons why the existing Asiatic flora or that of eastern North America is so much richer than that of Europe.

Among botanical items that I have not yet mentioned are species of *Ardisia, Mæsa, Liriodendron, Cinnamomum, Hakea, Mimusops, Diospyros*, stones of a *Nyssa* indistinguishable from our American *sylvatica*, as well as many others that might be enumerated. It must make the shade of Bentham turn over to have an Englishman identify the fruits of Proteaceæ in Europe.

All of the material is carpological, *i. e.*, the

[3] In Jongmans, W., "Rapport over zijne paleobot," *Rijksopsporing van Delfstoffen*, Jahren, 1908–11, pp. 23–25.

remains of fruits and seeds, which is supposed to be more certainly determinable than leaf impressions. It has been laboriously compared with recent material in the Kew herbarium and from other sources and is illustrated by enlarged photographs often showing the recent seed by the side of the fossil. One is impressed with the care with which the work has been done and the authors certainly merit the gratitude of their confrères. I venture to hope that they will feel called upon to give us the benefit of their experience in instituting a comparison, confessedly difficult, between their Pliocene fruit and seed floras of Reuver, Tegelen, Cromer, etc., and the abundant Pliocene floras represented by leaves in France, Italy and throughout southeastern Europe.

Edward W. Berry

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SPECIAL ARTICLES

THE MEASUREMENT OF OXIDATION IN THE SEA-URCHIN EGG

Because of its accuracy and convenience, Winkler's method of determining the amount of oxygen in solution has been almost exclusively used in the various studies of oxygen consumption of sea-urchin eggs. This method, as described in various texts of quantitative analysis, depends upon a chain of reactions, which result finally in the liberation of two atoms of iodine for each atom of oxygen originally present in solution. The investigator of egg oxidations measures the oxygen content of some sea-water before and after eggs have been contained in it. The usual procedure appears to be about as follows: The eggs are enclosed in a 300 c.c. bottle filled with sea-water and tightly sealed. At the conclusion of a certain time interval (usually an hour), the supernatant sea-water is siphoned off into a 250 c.c. bottle and tested for oxygen. From the value thus obtained, the oxygen concentration in the 300 c.c. bottle at the conclusion of the experiment can be computed, and thus if the original oxygen content of the sea-water is known, the amount of oxygen consumption is readily obtained by subtraction.

It is obvious that the ordinary Winkler method of determining oxygen loses its efficiency in the presence of any substance which takes up iodine. Now it is a fact that iodine absorbing substances are actually present in sea-water which has stood over sea-urchin eggs. This can best be shown by actual measurement of the iodine absorption of such "egg sea-water."[1] These measurements have been made a number of times. They show a small but quite constant value.

Of course after the eggs have been treated with any cytolytic agent, they give off to the sea-water very much larger quantities of iodine-absorbing substances.

Analytical chemists have suggested at least two methods of making Winkler determinations in the presence of organic substances. Perhaps the Rideal and Stewart method is the one most often used.[2] In this method the organic substances are oxidized by potassium permanganate in the presence of sulphuric acid. This method may do very well for most organic substances, but in order to oxidize proteins completely, hot concentrated permanganate solutions are necessary, and the dilute solutions recommended by Rideal and Stewart can accomplish but very little in the way of oxidations. The extensive literature on the oxidation of proteins by permanganate solutions can not be referred to here; the reader will find many references in Oppenheimer's "Handbuch der Biochemie."[3] In actual practise the Rideal and Stewart method has not proved satisfactory.

Another method is to determine the iodine-absorbing powers of the water which contains organic matter.[4] In this way a correction is obtained which is added to the value determined by the ordinary Winkler method. In measuring egg oxidations, this method is open to the objection that the sample chosen for the correction may not be truly representative of

[1] *I. e.*, sea-water which has stood over eggs.

[2] Rideal and Stewart, *Analyst*, XXVI., 141, 1901.

[3] Vol. 1, pp. 489–495.

[4] *Cf.* Lunge, "Technical Methods of Chemical Analysis," New York, 1908, Vol. 1, Part II., p. 783.

the entire volume of "egg sea-water." The presence of eggs at the bottom of the bottle makes impossible the thorough mixing which should precede the taking of a sample.

Sea-water which has stood over eggs in shallow beakers exposed to the air always gives much lower values for oxygen content than ordinary sea-water at the same temperature. The difference is of the same order of magnitude as the amount of oxygen used by the eggs in an hour. But it is not due to oxygen consumption, for the "egg sea-water" may be siphoned off and allowed to remain several hours in contact with air, so that equilibrium is certainly established. The difference is of course in part due to the iodine absorption of "egg sea-water," but not wholly so. For if we test a representative sample and obtain the necessary correction for iodine absorption, a difference still remains. If we assume that our method is accurate, we are led to the conclusion that the solubility of oxygen in sea-water is lowered by some substance or substances secreted by, or dissolved away from the eggs. This is not at all unusual, if we remember that Findlay and his collaborators have shown that many colloidal substances exert a well-marked influence on the solubility of gases.[5] Granted that our conclusion is correct, no method of measuring oxidations that depends on a change of oxygen tension (*e. g.*, the Warburg-Siebeck method[6]) is accurate. For any such method assumes that the oxygen solubility of the sea-water remains constant.

Another method of making determinations was devised in the summer of 1914. It was found that the iodine-absorbing substances normally given off by *Arbacia* eggs are colloidal. They do not diffuse through celloidin or parchment membranes. In the measurement of egg oxidations, therefore, the eggs may be enclosed in celloidin tubes instead of being allowed to lie free in the sea-water. Tubes of about 10 c.c. capacity and of narrow bore fit nicely into 300 c.c. bottles. At the conclusion of an experiment, the tube containing eggs is taken out, the bottle is filled to the top with sea-water of known oxygen content and is tested for oxygen by the Winkler method. The use of the celloidin tube has another advantage, in that oxygen determinations may be made in the same bottle in which the eggs were kept. Thus, siphoning is unnecessary and there is no error from this source. The tube method is, however, open to the objection that in the case of sea-urchin eggs at least, development can not take place if the eggs are too closely packed. Without modification it can therefore not be used for the measurement of oxidations during cleavage.

Determinations have been made both by this tube method and by adding corrections for iodine absorption. The results gained so far are not sufficiently accurate to warrant publication. They do show, however, that partial or complete cytolysis produced by dilute sea-water causes not an increase, but a decrease of oxidations.[7]

L. V. Heilbrunn

Woods Hole, Mass.,
July 26, 1915

[5] *Jour. Chem. Soc. Trans.*, XCVII., 536, 1910; CI., 1,459, 1912; CIII., 636, 1913; CV., 291, 1914.

[6] O. Warburg, *Zeit. f. physiol. Chemie*, XCII., 231, 1914.

[7] The tube method can not be used for completely cytolyzed eggs, as the egg pigment wanders through the walls of the celloidin tubes.

A BACTERIAL DISEASE OF WESTERN WHEAT-GRASS. FIRST ACCOUNT OF THE OCCURRENCE OF A NEW TYPE OF BACTERIAL DISEASE IN AMERICA

A very unusual type of bacterial disease has been found occurring on western wheat-grass, *Agropyron smithii* Rydb., in the Salt Lake Valley, Utah, and has been given considerable study by the writer during the current season. Although affected plants are usually somewhat dwarfed, the most striking characteristic of the disease is the presence of enormous masses of surface bacteria which form a lemon-yellow ooze or slime. Sometimes this bacterial slime appears in small droplets, but very often it is spread over the surface of the upper portion of the plant including the sheath, upper internode and inflorescence. The glumes which are badly attacked reveal bacterial layers of slime

between them. Sections of the spikelets show that the floral organs are extensively occupied by the bacterial organism which may be found filling the spaces between them. The disease seems to be that of the upper portion of the plant and has not been found on the roots or lower internodes and sheaths. There is produced a premature drying and bleaching of all the parts of the plant covered by the bacterial ooze. When the bacterial slime hardens it may be separated from the plant surface in the form of thin, lemon-yellow flakes.

At room temperature (25° C. ±) the organism grows very slowly on nutrient neutral agar. Plates that were thickly sown did not begin to show growth until the eighth day, while very thinly sown plates produced no bacterial colonies. However, the organism grows promptly on cooked potato, producing a viscid, lemon-yellow growth at the end of about the sixth day, but growth is apparent by the end of the second day. Organisms taken from a two-day cooked potato culture and stained with carbol-fuchsin, are about twice as long as broad and occur singly or in pairs joined end to end. A white organism which grows readily in agar is frequently found associated with the yellow organism.

This disease of western wheat-grass has many characteristics in common with Ráthay's disease of orchard grass (*Dactylis glomerata*, L.) caused by *Aplanobacter ráthayi*, E. F. S., and described by Ráthay[1] and later by Smith.[2]

First: The characteristic viscid, lemon-yellow slime forming layers over the uppermost leaves, the upper internodes and the different parts of the inflorescence is common in both dieases.

Second: The injury to the plants is due to the bacterial growth which first develops conspicuously on the surface and only later penetrates into the interior.

Third: The bacterial organism in both diseases produces a characteristic lemon-yellow growth.

Fourth: The best growth is made upon cooked potato; growth on agar is very slow and unless the organism is thickly sown growth does not readily take place.

Fifth: A white organism which readily grows on agar is frequently associated with the yellow organism in both diseases.

An extended study of the disease and the causative organism is in progress and the results will be published later.

P. J. O'GARA

DEPARTMENT OF AGRICULTURAL INVESTIGATIONS,
AMERICAN SMELTING & REFINING COMPANY,
SALT LAKE CITY, UTAH,
July 13, 1915

[1] Ráthay, Emerich, "Ueber eine Bakteriose von *Dactylis glomerata* L.," *Sitzber. der Wiener Akad.*, 1 Abth., Bd. CVIII., pp. 597–602, 1889.

[2] Smith, Erwin F., "A New Type of Bacterial Disease," SCIENCE, N. S., Vol. XXXVIII., No. 991, Dec. 26, 1913. "Bacteria in Relation to Plant Diseases," Vol. III., August 4, 1914.

REPORT OF THE SAN FRANCISCO MEETINGS OF SECTION F OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE opening session was held on Monday morning, August second, in San Francisco, in joint meeting with all other sections to listen to addresses of welcome and the address of the president of the Pacific Coast Division of the American Association for the Advancement of Science, Dr. W. W. Campbell.

In the afternoon, the Section adjourned to the University of California, Berkeley, where, in conjunction with the American Society of Naturalists and the American Society of Zoologists, the following papers were read.

On Wednesday, August 4, the affiliated societies made an excursion to Stanford University, at Palo Alto, and in the afternoon held a joint session with the American Genetic Association and the Eugenics Research Association.

The program for the San Francisco meetings was arranged by the following committee:

COMMITTEE ON PROGRAM

Charles A. Kofoid, chairman, University of California; Barton W. Evermann, California Academy of Sciences, San Francisco; C. H. Gilbert, Stanford University; Joseph Grinnell, University of California; S. J. Holmes, University of California; Vernon L. Kellogg, Stanford University; William E. Ritter, University of California; Harry Beal Torrey, Reed College, Portland.

JOHN F. BOVARD,
Acting Secretary for Section F

PROGRAM

Monday, August 2

Afternoon Session, Demonstrations

In charge of W. P. TAYLOR, University of California

Pacific Coast Crabs, F. W. Weymouth, Stanford University.

Papers: Conservation

BARTON W. EVERMANN, California Academy of Sciences, San Francisco, presiding

Opening Address, Charles A. Kofoid, University of California, acting vice-president, Section F, Zoology.

Conservation and Utilization of our Fur Seals (illustrated with lantern slides): GEORGE ARCHIBALD CLARK, Stanford University.

The paper pointed out the importance of the herd which has yielded twenty-six millions in revenue to the treasury since transfer from Russia in 1867. The seal herd was shown to be reduced to-day to one tenth its original size, with corresponding decrease of revenue. Two pertinent features of the natural history of the seals were discussed; first, the polygamous habit, on which land sealing, the removing of the surplus males—as in case of domestic animals—was based and conducted without injury to herd; second, the distant feeding and migration habit, which take the animals constantly outside the ordinary territorial jurisdiction and down in the Pacific to the latitude of Southern California each winter. The decline of the herd was shown to be due to indiscriminate hunting in the open sea, involving the death of gravid and nursing females with their offspring. This form of hunting was stopped after thirty-two years by treaty with Great Britain, Russia and Japan, signed in 1911, in which the United States pledged a share of its land catch of males to Canada and Japan in return for abandonment by their citizens of pelagic hunting. Congress in 1912 in enacting law to give effect to this treaty suspended land sealing also, cutting off vital consideration and jeopardizing the treaty, also involving half-million dollar annual loss and future detriment to herd through overstock of males. A review of government management showed mistakes and apparent inability to deal effectively with problem; marked by inefficiency of transient politically appointed agents and failure to utilize scientific investigations when made at intervals. The need of systematic and persistent expert care and study was shown to be imperative. Management through Treasury Department first and later by Department of Commerce both marked by failure. Transfer urged to Department of Agriculture, which in its biological survey and division of animal industry has experts and facilities necessary to deal with herd, whose problems are analogous to those of sheep, cattle, etc.

Condition of the American Seal Herd in 1914 (motion pictures of the fur seal): W. H. OSGOOD, United States Biological Survey.

A census of the American herd of fur-seals on the Pribilof Islands in 1914 shows in round numbers 295,000 seals, of which 93,250 are breeding females. This is an increase from 268,000 in 1913 and 215,000 in 1912, or nearly forty per cent. in two years. Although there are other considerations, this increase is due mainly to the treaty of 1911 by which pelagic sealing was stopped. The total number of animals is not large as compared with upwards of 2,000,000 which the herd once contained, but actually it is by no means small and it is reasonable to hope that with proper management a nearly or quite complete regeneration of the herd may be effected.

A very large proportion of the increase consists of young male seals and these, if permitted to come to maturity, will soon produce a large overstock of males of breeding age. This increase and the impending surplus of male life are due principally to a limitation of land killing imposed by a law passed by the congress of the United States in 1912. It has been and may well be contended that this law should not have been enacted. Whether or not the law at the time it was passed had any features deserving support (and this is of no present importance) it is evident that the restrictions imposed by it are now both unnecessary and harmful. That it should be radically changed or entirely repealed is so plain as to be scarcely open to argument.

Motion pictures taken in 1914 illustrate the peculiarities of seals of different classes, their appearance and habits, and sufficiently demonstrate in an incontrovertible way that the seal herd is not, as many suppose, on the verge of extinction. They show also the methods of enumerating seals, of driving, branding, killing and of taking and preserving skins.

The Recent History and Present Status of some Game and Fur-bearing Mammals of California: WALTER P. TAYLOR, curator of mammals, Museum of Vertebrate Zoology, University of California.

The present condition of the native animals of the world is such that the preservation of representative faunas is coming to be one of the important concerns both of zoologists and of governments in widely separated localities. California's list of mammals aggregates 369 species and subspecies, as compared with 80 for Kansas, 94 for Nebraska, 152 for Colorado and 182 for Texas. An examination of the recent history and present status of California's fur-bearing and game mammals, including the beaver, sea elephant, sea otter, deer, elk, mountain sheep, pronghorned antelope, black and grizzly bears, serves to justify according her a place among the important big game countries of the world. There has been a steady decrease in the original supply of wild life of the state dating from the beginning of the nineteenth century. It is coming to be realized that, particularly in a democracy, a special obligation to furnish leadership in movements for the perpetuation of the native fauna rests upon the professional zoologist.

The Administration of Fish and Game Laws: ERNEST SCHAEFFLE, executive officer of the California Fish and Game Commission.

Mr. Schaeffle declared that in California the administration of the fish and game laws during the last twenty years has been made easier through the support of public opinion and the fact that to the violation of the laws is attached a good deal of the same obloquy that attends the commission of larcenies and other unpopular misdemeanors. He denied the claim that California could have on sale the same quantity of game as Great Britain if the British system were followed and that the British system is better for both game and man. Moreover, he pointed out that the limiting of shooting to the aristocracy, even if it is a protection of a sort to the game, is un-American and besides that undesirable.

"In this country we feel that it is not only right but wise that man's instinct for sport be kept alive; would not certain European nations be better off in this crisis if their common people —boys and men—had been permitted to hunt, fish, learn to camp out—and to handle arms? We think so—and further, we think that a state or country where the average man knows how to shoot is safer, in times of peace and war, than those countries which are obliged to depend upon conscript armies of men whose experience with firearms is limited practically to the dismounting, assembling and polishing of their weapons."

One reason why fish and game laws are more cheerfully obeyed now, Mr. Schaeffle said, is that the laws that are framed now are based on knowledge and common sense and sensibly administered.

The Need of Scientific Research in Salmon Conservation: JOHN PEARL BABCOCK, commissioner of fisheries, Victoria, B. C.

It has been supposed that the key to fish conservation is found in artificial propagation, whereby the percentage of egg fertilization is increased, but this has not been proven. Examination of large runs after planting do not show evidence of man's assistance. Feeding in later stages is not well understood and has not been successful. Propagation concerns but a fraction of the fish's life history and even this portion has not been thoroughly investigated. Too much money has been expended on propagatory work and too little on the necessary scientific investigation which should precede such work. [Read by Barton W. Evermann.]

The Crab Problem of the Pacific Coast: F. W. WEYMOUTH, Stanford University.

Cancer magister, the edible crab of the Pacific coast, is found from Unalaska to Lower California in shallow water. It frequents sandy bottoms, feeding chiefly on small fish and crustaceans. The females lay in the fall from three quarters to one and a half million eggs, which are carried attached to the abdominal legs until they hatch three or four months later. The larvæ are free swimming for about four months, but on molting to the adult form in the summer, seek the bottom and take on essentially the habits of the adult.

The principal fisheries are at San Francisco and Eureka in California, Dungeness, Anacortes and Neah Bay in Washington and Boundary Bay and Prince Rupert in British Columbia. Fishing is carried on in shallow sheltered bays by traps similar to lobster pots, and on exposed bars or limited coves by means of hoop nets.

The edible crab was once extremely abundant through most of its range, but has been markedly reduced in such old and heavily fished localities as San Francisco, in spite of protective legislation. We see in the lobster fishery that neither abundance nor wide distribution has prevented depletion under persistent fishing, and that to-day the lobster is hardly holding his own though protected by stringent laws and aided by artificial hatching. It is much easier to conserve an existing fishery than to replace an exhausted one. We should, therefore, anticipate the future heavy fishing in still unexploited regions with laws designed

not for to-day, but for the conditions we soon must face. The following regulations, at present in force to varying extents in different districts, are recommended for the entire coast:

1. A size limit of $6\frac{1}{2}$ and preferably 7 inches, to be strictly enforced.
2. Complete protection of the females.
3. A closed season of three or more months covering the season, varying with the locality, during which soft crabs are taken.

Conservation of the California Elk: BARTON W. EVERMANN (read by title).

Tuesday, August 3

Morning Session, Demonstration

In charge of J. FRANK DANIEL, University of California

Improved Hydrogen Electrodes and Methods of Using Them, J. F. McClendon, University of Minnesota.

Papers: General Zoology

S. J. HOLMES, University of California, presiding

The Importance of Description and Classification in Philosophical Biology and in Education: W. E. RITTER, Scripps Institution for Biological Research, La Jolla.

The Physiological Analysis of Behavior: H. B. TORREY, Reed College, Portland.

Problems Concerning the Relation between Germ Cells and their Environment: BENNET M. ALLEN, University of Kansas, Lawrence, Kansas.

There is an increasing body of evidence to show that the germ-cells may be influenced by the environment. These influences may strike deep—injuring the germ-plasm so greatly as to produce abnormal development. They may bring about the appearance of mutants, as shown by Tower, MacDougal, Gager and others. In some forms the external influences upon the germ-cells produce only evanescent changes lasting but a few generations at the most. In still other cases they may merely serve to determine dominance in heredity. Sex determination in some forms at least appears to be brought about by these factors. The organism must be able to resist influences of the environment that are frequently met with in their normal life, otherwise animals and plants would be far more unstable than we find them to be.

Much needs to be done in studying the factors that govern the rhythm of germ-cell production, the increased or decreased fertility due to change of external factors such as climate, social life, etc., and the effects of domestication upon reproduction.

The recent marked increase in our knowledge of the glands of internal secretion shows how far-reaching may be their influence upon the organism as a whole. These and other substances present in minute quantities in the blood may well exert powerful influences upon the germ-cells.

Giant Fiber Action and Normal Transmission by the Nerve Cord of Earthworms: JOHN F. BOVARD, University of Oregon.

The peripheral nerves in a certain number of segments of an earthworm may be anesthetized and the nervous impulses responsible for locomotion will travel through the cord in the affected region. The distance which these impulses will pass without any reenforcement from muscular contractions is limited to about twenty ganglia. The rate at which these impulses are transmitted is a slow one and is about 22 mm. per second.

The giant fibers are not concerned directly with the locomotion, but with contractions of the longitudinal muscles in quick end-to-end movements. The speed of transmissions in these larger fibers is very rapid, 1,500 mm. per second. In regeneration from simple traverse section of the nerve cord, the recovery is very rapid, and the locomotor fibers resume activity before the giant fibers. When short pieces of the nerve cord are removed, recovery is much slower, but the order in which fibers transmit impulses again is the same as in simpler sections.

Drugs, such as stovaine, when applied to the cord show the same relations as in regeneration. The locomotor fibers recover first and the giant fibers later.

Afternoon Session, Papers: General Zoology

TREVOR KINCAIRD, University of Washington, presiding

The Action of Simple Reagents on Nerve Cells: W. A. HILTON, Pomona College, Claremont, California.

In order to learn something further in regard to the physical constitution of nerve cells, simple solutions which might act in various ways were used. In some cases the nervous tissues were treated directly with the reagent; in others the ganglia, or parts of the brain, were placed in boiling water first. Similar results were obtained by both methods. Acids, alkalies and other powerful reagents were used with the result that in almost every case a fibular groundwork for both

nucleus and cell body was revealed. A similar, but less dense perinuclear arrangement of fibrils was shown in nearly every case. Experiments with vertebrates and arthropods gave somewhat similar results, although the position of the cells and the surrounding parts differ. Living tissues were examined as a check, and by comparison the reticular arrangements of fibrils between and in cells were regarded as artifacts in most cases. Osmic acid gave the least distortion of any single reagent.

Observation on the Laws of the Correlation of Parts: J. C. MERRIAM, University of California (read by title).

Provision for the Study of the Anthropoid Apes: ROBERT M. YERKES, Harvard University.

It is doubtful whether there is any group of organisms of greater importance for biological study than the Anthropoidea. Nevertheless, our ignorance of most representatives of this suborder is more impressive than our knowledge. Of the anatomy, histology, embryology we know much, far from all; of the pathology, physiology and behavior of the apes, baboons and monkeys we know pitiably little: of their psychology and sociology, even less.

Surely it is high time to make provision for the thorough biological study of those organisms which are most similar to man and from whom, therefore, experimental pathology, genetics, psychology and the social sciences and technologies may be expected to obtain information of immeasurable theoretical and practical value.

The need of an anthropoid station is obvious. I know of only one attempt to provide facilities for the study of the apes. That has been made by the Germans in the Canary Islands. I have seen no published reports of data or progress, but through correspondence with the present worker, Dr. Wolfgang Koehler, I learn that observations have not been interrupted by the war. For reasons which may not be stated within the limits of this abstract, it seems wiser to establish an American station rather than to cooperate with the Germans.

There is abundant reason for supposing that the apes may be kept in perfect health over long periods and bred in Southern California. Hence it seems desirable to establish a station there rather than in the tropics[1] where the conditions are much less favorable for research.

[1] The possibilities of Borneo, Jamaica, Porto Rico and other tropical regions have been carefully considered.

The following plan is one which I hope may be carried out: In a suitable locality in California temporary provision might be made for the housing of sexually mature orang utans, chimpanzees and gibbons during a three-year test of the possibility of breeding. At the same time adolescent apes—and monkeys—could be studied by the staff of the station. Since my chief interest is in behavior and mind, I should wish first of all to arrange for the study of their instincts, ideational behavior and social relations. Three years of concentrated effort should add vastly to our knowledge of the behavior and psychology of the apes, as well as settle the practically important question of breeding.

If the apes, as well as the monkeys, can be bred satisfactorily in California, a permanent station should be established at which the most diverse aspects of the lives of the Anthropoidea (including man) might be studied.

Studies on Echinoderm Larvæ (illustrated with lantern slides): TH. MORTENSEN, University Museum, Copenhagen, Denmark.

These researches were undertaken mainly with the view of ascertaining whether there is any interrelation between the shape and structure of the larvæ and the natural relationship of the grown forms of the Echinoderms. They were carried out at the biological station at Misaki, Japan, in Australia, New Zealand, the Hawaiian Islands, and at the Biological Station, Nanaimo, B. C., during the time from May, 1914, till now.

In all the development of thirty-five different forms, mostly Echinoids, has been studied more or less completely. The results completely bear out the conclusions that the larvæ are of considerable value for classification, so that in cases of doubt about the systematic position of some form or other, the larval characters may settle the question; *e. g.*, the genus *Strongylocentrotus.* Within the regular Echinoids distinct family characters are found in the larvæ. Thus the larvæ of the family *Echinidæ* have in their first stage the main rod of their body skeleton elongated and more or less club-shaped, while in the families *Toxopneustidæ* and *Echinometridæ* the body skeleton in the first larval stage forms a sort of frame. In the larvæ of the *Temnopleuridæ* the main rod of the body skeleton is slightly elongated, with some characteristic processes. Previously not a single larva of any Temnopleurid or Echinometrid was known; now the development of three Temno-

pleurids and seven Echinometrids has been studied. Special interest attaches to the larva of *Echinobrissa recens;* it proves to have no likeness to the Spatangoid larvæ, but more so to the Clypeastroid larvæ, from which it is mainly distinguished by the rods of its processes being non-fenestrated.

A remarkable shortened development was found to obtain in *Laganum decogonale* and in *Toxocidaris erythrogrammus.* In the former the larval shape is still distinct, although rudimentary; in the latter there is no trace of larval processes, the embryo being simply worm shaped. A similar shortened development will doubtless prove to occur in the *Schiaster* occurring in the strait of Georgia.

By the successful rearing of the larvæ of a deep-sea species, *Lagunum fudsiyama,* it has been proved for the first time that typical pelagic larvæ may be found among deep-sea forms, and the possibility of studying the embryology of deep-sea forms is shown.

In other groups of Echinoderms the results are not yet sufficient for definitely establishing family characters in the larvæ. An interesting fact is that two species of *Asterina, A. pectinifera* (Japan), and *A. regularis* (New Zealand), have been found to have typical pelagic larvæ.

Hydrogen Ion Concentration in Stomach and Duodenum: J. F. McClendon, University of Minnesota.

The hydrogen ion concentration of the stomachs of normal persons after normal meals was measured every half hour by means of a hydrogen electrode lowered into the stomach or by removing a small sample. The hydrogen ion concentration rises rapidly after injection of the food and reaches a constant level $1\frac{1}{2}$ to $2\frac{1}{2}$ hours after finishing the meal. This level varies with the individual and approaches a limit of 1/10 normal $H+$.

The hydrogen ion concentration of the duodenal contents removed with the duodenal tube is about 2×10^{-8}.

The hydrogen ion concentration of the infant's stomach rises slowly after nursing and in one hour is about 6×10^{-6}. As the stomach empties the hydrogen ion concentration rapidly rises and becomes .01 normal 4 hours after nursing. The hydrogen ion concentration of the infant's duodenum is about 8×10^{-4} or nearly a thousandth normal and is sufficient for peptic digestion. Pepsin was always present in the infant's duodenum and therefore peptic digestion goes on there.

Parthenogenesis of the Frog's Egg: J. F. McClendon, University of Minnesota.

In 1911 I showed that the frog's egg may be caused to segment by a momentary electric shock, which takes the place of the spermatozoon. The immediate effect of the electric shock or the spermatozoon is increase in permeability since Na, K, Li, Mg, Ca, Cl, SO_4 and CO_3 diffuse out of the egg into the surrounding water at a faster rate. By very careful estimation of the chlorides with the Richard's nephelometer it was found that twice as much diffused out of the egg that had been stimulated electrically or fertilized as out of the unfertilized egg in distilled water. This increased permeability continues for 30 hours or perhaps longer.

The increased permeability protects the egg from swelling. Bachman and Rumstrom supposed the egg was protected by absorption of proteids, but they furnish no grounds for this assumption.

The increased permeability of the sea-urchin's egg lasts fifteen minutes after stimulation or fertilization and some fish eggs are impermeable to water and salt some time after fertilization. That stimulation and increased permeability are related is supported by the fact that increase in permeability of fish eggs is prevented by anesthetics.

Wednesday, August 4, Afternoon Session

Joint session of Section F, Zoology, the American Society of Naturalists, the American Society of Zoologists, the American Genetic Association and the Eugenics Research Association.

Demonstrations

In charge of Mary I. McCracken, Stanford University

Papers: The Rôle of Variation and Heredity in Evolution

David Starr Jordan, Stanford University, presiding

Heredity and Mutation as Cell Phenomena: R. Ruggles Gates, University of London.

Heredity consists in the perpetuation of the difference between related organisms. The older definition of heredity as the tendency of like to beget like is incomplete. Variations are divided into three classes, (1) those which are completely inherited, (2) those which are non-inherited, (3) those which are partially inherited; and these three kinds of variations must have very different evolutionary significance.

Mutations, or discontinuous variations, belong in the first class, and they are of many kinds, differing in their manner of origin and their manner of inheritance. Studies of the cell structure of mutants has made it possible to classify mutations into (1) those which are fundamentally morphological and (2) those which are primarily chemical. The hypothesis that each Mendelian character is the result of a chemical change in the nature of one chromosome in a germ cell, will account for not only the origin, but also the inheritance of every simple Mendelian character. Such a mutation is no more unlikely than mutations in bacteria, many of which are now known to occur. Each Mendelian pair of characters therefore represents a mutation which has occurred in past time.

The morphological mutations at present known consist in changes in the number of chromosomes in cell nuclei. The fundamental chromosome number in the genus *Œnothera* is 14, but *Œ. lata* has 15, *Œ. gigas* 28, etc. In these cases there has been a change in the constitution of the nucleus which may be considered to be morphological in nature. The change is propagated to every part of the organism by mitosis or cell division. Hence, for example, every cell of *Œ. lata* has 15 chromosomes, and the peculiarities of *Œ. lata* appear to result from this fact. One may conclude that each mutation, in plants at least, is a cell change originating in a particular germ cell and represented in every cell of the adult mutant organism.

The Idea of Multiple Causes as applied to Evolution: Wm. E. Ritter, Scripps Institute for Biological Research, La Jolla, California.

To be published later.

Seventeen Years' Selection of a Character Showing Mendelian Inheritance: Raymond Pearl, Maine Agricultural Experiment Station, Orono (read by title).

Are there such Things as Unit Characters? S. J. Holmes, University of California.

The doctrine that organisms are mosaics of independently varying elements is one that has figured largely in biological speculation from Darwin's time to the present. It is very intimately associated with many problems of heredity and evolution, and one is very liable to think in terms of the doctrine and unconsciously allow it to shape his opinions even though he may not avow his adherence to it. The doctrine is founded on the assumed independent variability of parts and the independent transmission of so-called characters. Many facts pointing to independent variability have been amassed by Darwin, De Vries and Weismann, and the latter has argued with especial force that it is impossible for several organs to be simultaneously perfected unless variations in the one occur independently of variations in the others. On the other hand, it may be pointed out that numerous variations have far-reaching correlations and that often a variation may be particularly manifest in some one feature, but nevertheless be the result of a general organic change which is only obscurely expressed in other parts of the organisms.

Mendelian inheritance which seems to lend support to the conception of the organism as a mosaic product is open to a quite different interpretation if we assume that what are segregated are not the bearers of unit characters merely, but the hereditary bases of organisms as wholes having this or that peculiarity. The bearing of the mosaic and organismal standpoints on various questions of evolutionary theory can be brought out only in the fuller paper of which this is a brief abstract.

Adaptation as a Process: Harry Beal Torrey, Reed College, Portland.

Some Genetic Studies of Several Geographical Races of California Deer Mice (projection of autochromes, with demonstrations and illustrations): F. B. Sumner, Scripps Institute for Biological Research, La Jolla, California.

Mice of the species *Peromyscus maniculatus* were collected in four regions of California, ranging climatically from the Mojave Desert to the humid northwest coast (Eureka). Fourteen characters of these mice have been measured, and the results subjected to statistical analysis. In general, the Eureka form (*rubidus*) differs more widely from the other three races than these do from one another, and hybridization has not thus far succeeded with it. *Rubidus* exceeds the others conspicuously in length of tail and foot, and to some extent in skull length and cranial capacity, comparison being made between animals of equal body length. This subspecies is also the darkest of the series. The increase in pigmentation, correlatively with increase in humidity, is a well-known principle to which these mice conform, but the increase in the length of the appendages toward the north (shown in *rubidus* and still more evident in Alaskan races) stands in contradiction to another well-known generalization, and is hard to reconcile with experimental evidence.

The subspecies *gambeli* from Berkeley or La

Jolla differs characteristically from the desert form (*sonoriensis*), but these differences relate almost wholly to pigmentation, that of the former being of a deeper shade and more extensive in distribution. Hybridization between these two races has proved easy, but I am not yet prepared to report upon the results.

The desert race has been transferred to the humid atmosphere of Berkeley and reared successfully. Neither the parent animals, nor an F_1 nor an F_2 generation has shown, however, any perceptible approach to the Berkeley type of coloration.

Some interesting modifications have resulted from captivity. Mice of the subspecies *gambeli* and *sonoriensis*, which have been reared from birth in confinement, have been found to differ from wild ones in having a distinctly shorter tail, foot, innominate bone and femur. No significant difference has been found in cranial capacity.

These experiments are being continued at the Scripps Institute, La Jolla.

Fossil Insects and Evolution: T. D. A. Cockerell, University of Colorado, Boulder, Colorado.

The U. S. National Museum possesses a very interesting series of English fossil insects, which originally formed part of the Brodie collection, but came into the possession of Lacoe, and finally reached the museum with the Lacoe collection. In the course of working over these specimens, occasion was taken to review the fossil insects of the British Islands, and incidentally to consider the mesozoic insects of other countries. Since this work was done, it has been ascertained that the British Museum possesses very much larger collections from the same source, which it is hoped to describe during the coming fall and winter. Mesozoic insects are of special interest because it was during this epoch that most of the modern families were established. The rise of the higher flowering plants was necessarily contemporaneous with a great development of insect life, and all the main outlines of this development were certainly completed before the beginning of the Tertiary. Unfortunately our knowledge of Mesozoic insects is extremely defective, but we know enough to reach some interesting conclusions. The English Lias contained great numbers of Coleoptera, and not only were several of the modern families apparently well established, but some of the species showed a well-defined elytral pattern of longitudinal dark stripes or bands, quite like the pattern seen in various living beetles, and varying in the same manner. Thus the outlines of elytral ornamentation, which might be imagined to be recent and unimportant, are actually of enormous antiquity, having been laid down before there were any Lepidoptera, so far as we know, and even prior to the appearance of Hymenoptera.

Great advances have been made in recent years in our knowledge of Tertiary insects, with the result of showing that on the whole progressive evolution has been extremely slow, most of the new species and even genera coming into existence by a shuffling, as it were, of old characters. Wheeler's researches on the ants of the Baltic amber have shown that in the Oligocene the Formicoidea were almost or quite as far advanced as they are to-day. A comparison of the Miocene Bombycid flies with those of to-day shows that at least in certain features, the fossils are not rarely more specialized than their modern representatives. The Garnet Bay Oligocene, a deposit in the Isle of Wight, is full of beautifully preserved insects, and when these have all been worked over we shall know a great deal about the English insect-faunas of that period. The work so far done confirms the general opinion that evolution has been very slow since that period, say within the last two million years. Where genera are strikingly different from those now living, they have simply become extinct. All this is of course very different from the condition among the mammalia. We are bound to conclude that the rate of evolution is extremely different in different groups of animals. The insects are fairly comparable with the Mollusca in this matter, but with this great difference, that the number of species of insects is enormously greater, and the adaptations are much more numerous and more diverse. The great stability of the main features of insect organization is therefore more remarkable. On the other hand, we find in the rocks many evidences of insect migrations, or of the former existence of families and genera where they are now extinct; so that we are cautioned against assuming too much from the present distribution of groups of insects. Insects are in general mobile creatures, and, given vast periods, may readily travel over the greater part of the habitable world. They are, on the other hand, commonly dependent on particular sets of conditions, and thus they are likely to be locally exterminated, the general result being a shifting of insect populations in the course of time, obscuring the original centers of distribution.

H. V. Neal,
Secretary

(*To be continued*)